University of Cambridge
School of Agriculture Memoirs

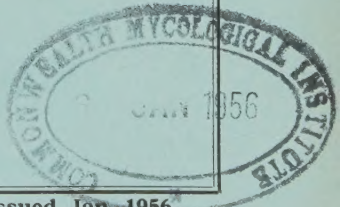
Memoir No. 27

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1954—Sept. 30th, 1955.

Review Series

No. 10. Crop Husbandry Experiments in Cambridge

CAMBRIDGE
1956



Price 3s. 0d. Post Free

Issued Jan. 1956.

FOREWORD

This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible by means of author summaries the contributions made by members of the Staff of the School of Agriculture and its Associated Research Organisations to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published.

Requests for further information or criticism arising out of the summaries should be referred to the individual author concerned ; criticisms and suggestions for the improvement of the Memoir itself should be addressed to the Librarian of the School.

The Librarian takes this opportunity of thanking all those who have kindly sent literature during the past year.

Correspondence relating to the Memoir and Publications sent in exchange should be addressed to :

THE LIBRARIAN,
SCHOOL OF AGRICULTURE,
UNIVERSITY OF CAMBRIDGE,
CAMBRIDGE,
ENGLAND. (Tel. No. CAMBRIDGE, 2485, Ext. 17).

University of Cambridge
School of Agriculture Memoirs

Memoir No. 27

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1954—Sept. 30th, 1955.

Review Series

No. 10. Crop Husbandry Experiments in Cambridge

CONTENTS

	PAGE
STAFF	3
CROP HUSBANDRY EXPERIMENTS IN CAMBRIDGE, by F. Hanley	5
SUMMARIES	11
Agricultural Economics	11
Agriculture	12
Animal Breeding and Genetics	13
Animal Nutrition	14
Animal Pathology	15
Animal Physiology and Production	16
Crop Pests and Diseases	20
Plant Breeding and Genetics	23
Plant Ecology	23
Soil Science	24
Statistics	25
Miscellaneous	26
Books Received	27
Library Lacunae	29
Author Index	*inside back cover*
Publications	*back cover*

FACULTY OF AGRICULTURE

I. GRADUATE STAFF

DRAPERS PROFESSOR OF AGRICULTURE

SIR F. L. ENGLEDOW, C.M.G., M.A., F.R.S. (*Joh.*)

EMERITUS READER

J. HAMMOND, C.B.E., M.A., F.R.S. (*Down.*), Agricultural Zoology and Physiology.

READERS

F. HANLEY, O.B.E., M.A. (*Joh.*), Crop Husbandry.
H. H. NICHOLSON, M.B.E., M.A. (*Selw.*), Soil Science.
J. WISHART, M.A., D.Sc. (*Lond.*), (*Clare*), Statistics.
H. E. WOODMAN, M.A., Ph.D. (*Gött.*), D.Sc. (*Leeds*), (*Down.*), Animal Nutrition.

UNIVERSITY LECTURERS

M. G. BARKER, M.A. (*Trin.*), Agricultural Implements and Machinery.
A. J. BROOKES, M.A. (*Selw.*), Agriculture.
S. DICKINSON, M.A., M.Sc. (*Wales*), (*Emm.*), Plant Pathology.
R. E. EVANS, Ph.D. (*Caius*), Animal Nutrition.
D. G. GILMOUR, Ph.D. (*Cath.*), Agricultural Zoology and Physiology.
J. HAMMOND (Jr.), M.A. (*Chr.*), Agricultural Zoology and Physiology.
F. G. W. JONES, M.A. (*Jesus*), Agricultural Entomology.
P. H. LOWINGS, PH.D. (*Queen's, Belfast*), Agricultural Mycology.
J. LINE, M.A. (*Emm.*), Agricultural Botany.
W. J. RIDGMAN, M.A. (*Queens'*), Agriculture.
MISS E. H. WHETHAM, M.A. (*Newnham*), Gilbey Lecturer in the History and Economics of Agriculture.

ASSISTANT DIRECTOR OF RESEARCH

E. C. CHILDS, Sc.D. (*Clare*), Soil Physics.

UNIVERSITY DEMONSTRATORS

D. F. EVERED, PH.D. (*Lond.*), Animal Nutrition.
Q. A. GEERING, M.A. (*Jes.*), Agricultural Entomology.
R. J. HALLEY, M.A. (*Emm.*), B.Sc. (Agric.), Dip. Dairy Husbandry (*Reading*), Agriculture.
D. E. G. IRVINE, Ph.D. (*St. Andrews*), Agricultural Botany.
K. E. KIRKHAM, M.A. (*Fitzw.*), Animal Physiology.
A. LAZENBY, M.A., M.Sc. (*Wales*), Agricultural Botany.
D. M. MCALEESE, Ph.D. (*Queen's, Belfast*), Soil Science.
J. PALMER, M.A., M.Sc. (*Dunelm*), Agricultural Engineering.
R. M. S. PERRIN, M.A. (*King's*), Soil Chemistry.
J. D. WHITEAR, M.A., Agriculture.

ASSOCIATE LECTURER

F. G. STURROCK, M.A. (*Trin.*), Agricultural Economics.

OTHER LECTURERS

R. C. CAMPBELL, PH.D. (*Caius*), Statistical Methods.
H. I. FIELD, M.Sc. (*Wales*), M.R.C.V.S., Animal Hygiene.
E. A. GIBSON, B.Sc. (*Lond.*), M.R.C.V.S., Animal Hygiene.
J. HAMMOND, C.B.E., M.A., F.R.S. (*Down.*), Agricultural Zoology and Physiology.
E. LAWRENCE, O.B.E. (*Fitzw.*), Tropical Agriculture.
M. S. PEASE, M.A. (*Trin.*), Animal Genetics.

ASSISTANTS IN RESEARCH

B. W. BACHE, B.A. (*Oxon.*), Soil Science.
M. G. BRUSH, B.Sc. (*Edin.*), Animal Physiology.
H. T. TRIBE, Ph.D. (*Lond.*), Soil Microbiology.

DIRECTOR OF ADVANCED STUDENTS

F. HANLEY, O.B.E., M.A. (*Joh.*).

THE UNIVERSITY FARM

W. S. MANSFIELD, C.B.E., M.A. (*Emm.*), Director.
J. HODGES, M.A. (*Down.*), B.Sc. (*Reading*), Farm Demonstrator.
R. H. JARVIS, B.A. (*Down.*), Farm Demonstrator.

SECRETARY

G. G. KERR, M.A. (*Trin.*).

II. STAFFS OF THE RESEARCH ORGANISATIONS ATTACHED TO THE SCHOOL OF AGRICULTURE

POULTRY GENETICS STATION

M. S. Pease, M.A. (*Trin.*), Director.
A. G. Cock, M.A. (*Corpus*).

PROVINCIAL AGRICULTURAL ECONOMICS SERVICE

F. G. Sturrock, M.A. (*Trin.*), Provincial Agricultural Economist.
C. S. Barnard, M.A. (*Queens'*).
G. H. Brayshaw, M.A. (*Clare*).
J. S. Conroy, B.A. (*W. Australia*), M.A. (*California*).
P. E. Graves, M.B.E.
P. G. James, M.A. (*Wales*).
R. A. Mackness, M.A. (*Joh.*).
P. E. Naylor, B.A., Dip.Ag.Sci. (*Pemb.*).
J. S. Nix, B.Sc. (Econ.), (*Exeter*).
Miss S. Vincent, B.A. (*Newnham*).
D. B. Wallace, M.A. (*Queens'*).

SOIL PHYSICS UNIT

E. C. Childs, Sc.D. (*Clare*), Director.
N. Collis-George, Ph.D. (*Fitzw.*), M.Sc. (*Manchester*).
E. G. Youngs, B.Sc. (*Lond.*).

OTHER RESEARCH STAFF

R. A. Dunning, Ph.D. (Queens'), Sugar Beet Pests.
A. N. Ede, B.A. (*Cath.*), Drainage Engineering.
F. Moriarty, Ph.D. (*Lond.*), Sugar Beet Pests.
N. E. Rider, B.Sc. (*Lond.*) (*Seconded from the Meteorological Office*), Meteorology.
Miss A. M. Shepherd, Ph.D. (*Lond.*), Sugar Beet Pests.
H. R. Wallace, Ph.D. (*Liverpool*), Sugar Beet Pests.
T. D. Williams, B.A. (*Oxon.*), Potato Root Eelworm.

COMMONWEALTH BUREAU OF PLANT BREEDING AND GENETICS

P. S. Hudson, Ph.D. (*Trin.H.*), Director.
R. H. Richens, M.A. (*Selw.*), Assistant Director.
Miss T. Ashton, M.A. (*Girton*).
B. Heiseler.
Miss O. Holbeck, B.Sc. (*Lond*).
A. H. Welsh, M.A. (*Oxon.*).

III. DEPARTMENTAL LIBRARY

LIBRARIAN

F. A. Buttress.

CROP HUSBANDRY EXPERIMENTS IN CAMBRIDGE*

By

F. HANLEY, O.B.E., M.A.

(*University Reader in Crop Husbandry*)

The history of the foundation and development of the School of Agriculture, recounted in an earlier Memoir (1), tells how experiments in crop husbandry were first organised by the Cambridge and Counties Agricultural Education Committee in 1894. In that year, T. B. Wood returned to Cambridge to act as Secretary of the Committee, to teach Agricultural Chemistry and to supervise manurial experiments at a number of centres established by the Norfolk Chamber of Agriculture and by the County Councils of some of the other Eastern Counties. The results of these experiments were first published separately by the bodies concerned but in 1897 it was agreed that the results for that and for succeeding years should be published as an annual joint report prepared by T. B. Wood.

The crop experiments in these early years were chiefly concerned with (a) rotation experiments on the value of dung and fertilisers ; (b) seeds mixtures for temporary leys and (c) manurial experiments on permanent and rotation grass. Although only single or duplicate plots of each treatment were used, the experiments were repeated at several centres and led to many conclusions which have since been supported by results from replicated trials, namely, that nitrogenous manures increased yields of hay, favouring the grasses at the expense of the clovers, whereas phosphatic and potassic fertilisers had less effect on yield (except P_2O_5 on some clay soils) but strengthened the clovers in the sward. At that time fertilisers were used by very few farmers, even for potatoes, and on the requirements of the separate plant food elements there was virtually no understanding among practical men.

In 1898 and 1899 experiments were started on the manuring of potatoes on various soil types including black fen peat and fen silt. On fen peat, superphosphate at 7–8 cwt. per acre seemed to be the best treatment and on silt 5–6 cwt. superphosphate with 1 cwt. sulphate of potash. Little benefit was found from potash or nitrogen on black fen nor from nitrogen on fen silt. Striking results were also obtained from the use of superphosphate for mangolds on black fen soils, suggesting that " superphosphate is of special value throughout these flat low-lying lands " (2).

In 1899 the University gave formal recognition to the School of Agriculture as a Department of the University. With Dr W. Somerville as the first Draper's Professor of Agriculture, it was natural that increased attention should be paid to the improvement of pasture, using sheep to test the effects on similar lines to the experiments already in progress at the farm of the Northumberland County Council at Cockle Park. At the heavy land centres, heavy dressings of phosphate, especially in the form of basic slag, greatly improved the pasture and led to marked increases in the liveweight gain of the sheep grazing the plots. No such response to phosphate, or indeed to other manures ,was found on light soil. T. H. Middleton (3, 4), who succeeded Somerville as Draper's Professor of Agriculture in 1902, discussed the reasons for the different results on the different soil types, attributing the beneficial effects of phosphate on heavy soil to its influence on wild white clover and came to the conclusion (3) that " . . . any pasture capable of growing clover may be rapidly improved by the free use of phosphates " and " the extent to which pastures may be improved, and the rate at which they may be improved by phosphates, will be directly proportional to the capacity of the soil or pasture for growing clover, more especially white clover ". For pastures on light and medium soils he concluded (3) " no manure is likely to be so grateful as the droppings of animals fed upon the land, and the surest way to improve the condition of the pasture is to employ cotton cake or similar feeding-stuffs to supply nitrogen, with light dressings of superphosphate and of kainit if it be proved that the land is in need of these mineral manures ".

Other experiments in these early years, especially at Bramford in East Suffolk, showed the great importance of potash for lucerne on poor light gravelly soil (5). Lack of response to manures for many arable crops on the light soil at Bramford led the East Suffolk County Council to hire a field of heavy Boulder Clay near Saxmundham where rotation manuring experiments, started in 1899 in collaboration with the School of Agriculture, were continued for some 50 years and have been instrumental in showing the importance of manuring, especially the use of phosphatic manures, for arable crops on such land.

In 1900 the University was able to hire Burgoyne's Farm at Impington, 3 miles from Cambridge, on soil chiefly light and medium loam in texture. Here a wide range of experiments was carried out during the succeeding decade, including not only cereal breeding and variety trials but also experiments on many husbandry problems such as the control of charlock in cereal crops; manuring and varieties of potatoes, mangolds and sugar beet; effect of cutting setts, size of sett, planting distance, sprouting in trays and change of " seed " on the yield of potatoes. Experiments on the formation of permanent pastures at Burgoyne's and on other farms in East Anglia and the East Midlands included manuring and seeds mixture trials and a detailed study of the density and botanical composition of the herbage of old pastures, including variations in the proportions of component species at different seasons of the year (6). Rotation experiments were also commenced at Burgoyne's Farm in 1903 (a) to study the manurial requirements of a 4-course rotation of crops (mangolds, oats, " seeds " for hay, wheat) and the best place in the rotation to apply the manures and (b) to compare the effects of dung from fattening cattle fed on a ration including linseed cake with those of dung from similar

**This is the tenth of a series of articles summarising phases of agricultural research particularly associated with the School of Agriculture since its inception, previous contributions having dealt with:—Physiology of Reproduction, Plant Virus Research, Plant Breeding, Animal Nutrition, Horticulture, Agricultural Economics, Field-Drainage, Animal Production, and the Cambridge University Farm. Further contributions on other work will appear in future issues.*

cattle fed no cake. These rotation experiments, together with the ones at Saxmundham, Bramford and elsewhere in East Anglia, show the keen interest at that time in the problem of residual effects of manures and fertilisers.

In 1907, T. H. Middleton left Cambridge and was succeeded by T. B. Wood as Draper's Professor of Agriculture. In 1910, the lease of Burgoyne's Farm, Impington expired but the University was able to lease Gravel Hill Farm, within 1½ miles of the School of Agriculture, and this has remained in the occupation of the School ever since, adjacent land being added from time to time.

The outbreak of the First World War came before any extensive programme of experiments had been started on Gravel Hill Farm and it was not until the appointment of Arthur Amos in 1919 as Lecturer in Agriculture that a scheme of crop husbandry experiments began to take shape.

Amos began an intensive study of crop ensilage and, in collaboration with H. E. Woodman, studied the changes that take place when a green crop is ensiled (7, 8), the effect of conditions in the silo on those changes and on the resulting type of silage and the losses that occur when a crop is ensiled. The work of Amos and Woodman covered several crops (9–12) and ensilage in both towers (13) and clamps (14), whilst Woodman and F. Hanley made a similar study of stack silage (15). This work on silage made it possible to state the requirements for the production of good silage in terms of type, maturity and method of handling the crop, and consolidation and temperature in the silo (16). Amos also carried out experiments on the feeding of silage.

With the spread of the sugar beet crop in the 1920's ,Amos (17) carried out experiments in 1924 and 1925 on the University Farm showing the beneficial effect of subsoiling and of early singling on yield of beet. These experiments were among the first on the University Farm carried out in a way that made it possible to use statistics to calculate a probable error. Wood (18) had earlier recognised the importance of the application of statistics to agricultural experiments. The study of this subject was further advanced by G. Udny Yule, who was appointed University Lecturer in Statistics in the School of Agriculture in 1912, and eventually Field Experimentation developed as a subject of study in its own right.

Experiments on the spacing and manuring of sugar beet were carried out from 1927–1929 by Hanley (19) on the fen soils of Huntingdonshire and the Isle of Ely and showed the influence of plant population and early sowing on yield of roots and sugar, though little response was obtained to applications of fertiliser, except on the poorer types of light peaty fen which, because of their unsuitability for the potato crop, had not received heavy applications of fertiliser elsewhere in the crop rotation.

Other work on the sugar beet crop undertaken at this time was the treatment of the " seed " in an attempt to produce single true seeds by breaking down the seed clusters by removal of the seed coat. No satisfactory method of milling was found but treatment with sulphuric acid proved suitable for small experimental samples and Hanley and R. M. Woodman (20) showed that seed treated in this way had a greater proportion of single seed " clusters " and " brairded " a few days earlier than untreated seed. Further experiments on the use of acid-treated seed were carried out on the University Farm in 1929–1931 by F. H. Garner and H. G. Sanders (21) and at other centres by Hanley (22) in conjunction with several County Agricultural Organisers. These experiments showed quicker germination and a larger plant population, which often led to a larger yield of beet, from acid-treated than from untreated seed, whilst seed that had been mechanically milled usually gave results approximately as effective as treated seed.

Early single plot cultivation studies on such problems as subsoiling and stubble cleaning by Amos in the 1920's were followed by more precise studies by Garner and Sanders (23–25) on the preparation of a seed bed for winter wheat after potatoes, spring cultivation for autumn-sown wheat and the effect of the gyro-tiller on crop yield. As with so many attempts to evaluate cultivation practices in terms of crop yield, the most striking result of these investigations was perhaps the general absence of any marked differences between the effects of the treatments compared, except perhaps in the investigation into seed-bed preparation where the results generally favoured the use of the plough as compared with the cultivator,except in extremely dry soil conditions when all cultivations had little effect. Rolling and harrowing in spring had little or no consistent effect on yield of wheat, nor had the use of a gyro-tiller for a number of crops whether on light or heavy soil. Parallel with the investigations by Garner and Sanders, C. Culpin (26, 27), made a more detailed study of the relation between cultivation implements, soil structure and the crop. Tests of soil compactness, resistance to penetration, degree of comminution and permeability showed that gyro-tilling as compared with ploughing initially produced a loose and open soil to depths of 12 to 18 inches on both light and heavy land and this greater looseness in the surface layers was demonstrable for over a year on heavy soils and in the subsoil for upwards of a year on both light and heavy land. Culpin (28) also showed that the exact actions of rolls differ widely according to the circumstances in which they are used and suggested that tests of the effect of rolling on crop yield should be accompanied by tests to measure the exact effects of the rolling on the soil itself in order to determine when and how rolling may be beneficial.

Another problem investigated was the effect of the age of seed beans on the yield of crop. Garner and Sanders (29), in experiments carried out over a period of three years with two strains of beans, compared old and new seed. In general, new seed gave slightly higher yields (about 10%) than old seed but there was some evidence that weather conditions when the seed was harvested might be more important than age.

F. L. Engledow's studies of the factors underlying yield in the field stimulated the development of field experimentation generally in crop husbandry research and two problems he studied were the subject of further investigation by other workers at Cambridge, namely the nitrogenous manuring of wheat (30) and plant population studies (31–33).

Garner and Sanders (34) investigated the effect of time of application of sulphate of ammonia to autumn-sown wheat. They found that early dressings did not affect germination or plant establishment but tended to increase tiller formation by the end of February and the number of ears at harvest whilst late (May) dressings tended to increase ear size. They found that the optimum time of application in any season will depend on

weather conditions, a very wet winter making autumn applications ineffective and May dressings being very beneficial provided rainfall in June suffices to wash them in. They concluded that half the dressing should be applied early and the other half reserved for May application.

A study of the relation between closeness and evenness of plant on the one hand and yield on the other, made by Engledow in the late 1920's, was followed in the 1930's by experiments on seed rates by Garner and Sanders and later by H. G. Hudson's work on population studies with wheat. In these investigations Hudson (35) first studied the optimum size and shape of sampling units and the optimum sampling percentage in trials with wheat growing under farm conditions. He found the optimum size and shape of sampling units to be about 3 feet of each of 2 adjacent drill rows. The optimum sampling percentage was shown to be affected by size of plot and degree of sub-division ; the smaller the plot the greater the percentage which must be taken and the greater the degree of subdivision for sampling the lower the sampling requirements. For $\frac{1}{20}$th acre plots, 3 to $4\frac{3}{4}$% will give an adequate sample but the percentage rises with fall in plot size until for $\frac{1}{600}$th acre plots 43% is necessary. In later studies on wheat, Hudson (36) investigated the problems of propinquity and showed that the yield of any unit of 6 in. of drill row is significantly affected by the number of plants in adjacent units. Competition is primarily underground for water, soil nutriments and soil air ; competition for water is most important in determining yield. Hudson concluded that the variation of plant number from unit to unit in a field of wheat, caused chiefly by irregularities of the seed drill, does not cause undue loss of yield of grain. Hudson (37) also considered the discrepancies often found between nursery plots and field plots when investigating yield problems with wheat. He showed that the intensity of competition for water and soil nutriments influences the optimum plant density, and that a high intensity of competition is associated with a low optimum plant density.

The need to raise sugar beet yields as the subsidy decreased led Engledow (38) to study the effect of a full plant and correct placing on yield. Using the same procedure formerly used in investigations on cereal yield, namely the "Census of an Acre" method, he and his co-workers studied fields of sugar beet on different soils and levels of husbandry in Cambridgeshire, Hertfordshire and Norfolk. He concluded that the high fluctuation in the average number of plants per foot length of row must be primarily due to the faulty action of the seed drill. It was shown that unevenness of the seedling population made singling costly and a full, even, final plant impossible. Few casualties occurred among plants between singling and harvest and although where roots were far asunder they were above average in size, these spatial responses in no sense compensated for paucity of plant. Engledow concluded that irregular plant was primarily responsible for ordinary fields of beet failing to reach the maximum potential yield and that, in turn, irregular plant was induced by a number of influences of which faulty seed drill action was the chief. He concluded that on rows 16–18 inches apart, a seeding of 17lb. per acre was best and that lighter seedings of 10–12 lb., though suitable in very favourable circumstances, are in general not dependable.

Further experiments on the spacing of sugar beet were carried out by Garner and Sanders (39, 40) in 1934 and 1936 with the object of studying the effect of gaps under varying spacing conditions. The results showed that roots immediately surrounding a gap partly compensated for the missing plants, the extent varying from 80–90% in a dry year to 41–84% under various spacing arrangements in a wet year ; the allocation to the individual plants surrounding a gap was approximately inversely proportional to the square of their distance from the site of the gap. It was also found that within classes of beet similar in regard to spacing treatment and gappiness, there still remained considerable variation due to soil and to genetic heterogeneity.

Further statistical examination of the data from these experiments by G. B. Hey and W. F. F. Kemsley (41) enabled estimates to be made of the effects of missing beet on final yield and of the yield to be obtained with various percentage plants. The distribution of gaps over the field was found to be non-random ; the percentage of gaps did not differ greatly between the spacings tried.

These experiments threw no light on the question of whether optimum spacing is related to the level of fertility of the field but in further experiments in 1937 and 1938, Garner and Sanders (42) found no interaction between row distance and level of manuring ; in other words, optimum row distance did not depend on level of fertility.

Following the experimental work on grassland in the early years of the century, there was a considerable lapse of time before further experimental work on grassland was undertaken in the 1930's. By that time, the application of statistics to agricultural experimentation had come to be regarded as essential and attempts were made to apply statistical principles in a new series of grassland experiments. These experiments were stimulated by the work of T. B. Wood, H. E. Woodman and others on the nutritive value of pasture grasses as affected by various conditions of environment and management, including manuring, and some of them were carried out in co-operation with county agricultural staffs.

A series of experiments on the effect of frequent application of sulphate of ammonia to permanent grassland in East Anglia was reported by Hanley (43) and drew attention to the fact that such treatment cannot be relied upon to bring about a substantial rise in the level of production at times when, for other reasons, natural production is at a low level. These results emphasised the need for more definite information as to a means whereby an early bite can be assured and production during the dry periods in June, July and August might be increased to a level more nearly approximating that at the flush periods of the year.

Experience of the risks involved in carrying a large head of stock in circumstances where summer grazing may be severely restricted by drought, led to the introduction of lucerne-cocksfoot leys as part of the ordinary cropping system on the heavy land of the University Farm in the 1930's and this in turn led to experimental work both before and after World War II on problems in the establishment, treatment and management of lucerne and lucerne-grass mixtures.

Experiments by Garner and Sanders (44) showed that lucerne drilled at a constant seed rate per acre in narrow rows ($3\frac{1}{2}$″ and 7″) gave a greater yield per acre than when drilled in rows $10\frac{1}{2}$″ and 14″ apart and

provided no evidence that weed infestation is reduced by close drilling. The broadcasting of trefoil at the time of drilling the lucerne had no effect on total yield or on weed infestation. Wild white clover broadcast at the time of drilling the lucerne slightly reduced the yield of lucerne but gave some control of weeds. Broadcasting commercial cocksfoot seed at the time of drilling the lucerne led to very considerable increases in total yield, particularly during the spring, and to some loss of lucerne plants, but the cocksfoot almost completely controlled weeds and its mixture with lucerne proved very suitable for hay or for silage. Subsequently, in farm practice, the same mixture was used for grazing, especially at times of the year when, under dry summer conditions, grazing on grass and clover leys was scarce and its use for this purpose has become standard practice on the University Farm.

A series of experiments on seeds mixtures for 4-year leys on the heavy land of the University Farm was carried out by Garner and Sanders (45). The seeds mixture trials also tested the desirability of including late-flowering red clover in the seeds mixture for a 4-year ley and compared grazing with cutting for hay in the first harvest year. Most of the red clover survived for the first two years of the ley, during which it increased the yield of dry matter very markedly ; it did not lead to any reduction of yield in the last two years of the life of the ley. By producing an early cover of the ground, red clover helped to check the encroachment of weeds ; although its presence also led to a reduction in the proportion of wild white clover in the herbage in the later years, this reduction was not serious. Under favourable conditions for establishment of the young plants, grazing was more beneficial to the sward than cutting for hay during the first harvest year. When the plants were slow to establish, particularly in a very dry spring and summer, grazing checked the development of the sward and cutting for hay gave better results.

Other experiments, started in 1931 and continued for 6 years, compared 3 types of basic slag and also superphosphate and ground mineral phosphate as sources of phosphate for old permanent grass. Marked effects (over a period of some 6 years) were obtained from the basic slags and superphosphate, all of which gave considerably higher yields in the early years of the experiment. The effects on total annual yield, however, were much smaller or insignificant in the fifth and sixth years after the application of the fertilisers. There were no important differences between 3 types of basic slag (high grade, low grade and Bessemer) and superphosphate gave as good results as the basic slags. The ground mineral phosphate failed to produce any effect and gave no better yield than plots receiving no phosphate. In general, the basic slags and super phosphate produced their most marked effect on yield in the early part of each season ; they produced big increases in the proportion of clover in the herbage during the early years of the experiment, increasing it by some 50%, but these differences became less marked and in some cases were reversed in the later years.

Throughout the period when the Ministry of Agriculture's Advisory Services for the Eastern Province were centred in the School of Agriculture, much co-operative work on the use of manures and fertilisers and of trace elements was carried out on farms in the Eastern Counties, thus continuing the tradition established in the 1890's. Many of the results of these experiments have been included in bulletins and memoranda published by County Councils and Government Departments and others have been reported by Hanley (46–49). In the latter category were experiments carried out in 1932–1935 on the placement of fertilisers for barley and sugar beet (50). Combined seed and fertiliser drills, though widely used overseas, were relatively rare in this country at that time and these experiments showed that beneficial effects could be obtained by placing normal amounts of fertiliser near the seed of barley, provided the soil conditions were not very dry, but that there was considerable risk to germination and brairding if the same practice was adopted for sugar beet, except for small quantities of phosphate and nitrogen sown down a separate coulter and therefore not in direct contact with the seed.

During World War II, experimental work in crop husbandry on the University Farm was suspended owing to the transfer of the members of the staff concerned to war-time duties away from Cambridge. Co-operative experiments with County Staffs in the Eastern Counties continued but these were almost exclusively directed to the investigation of *ad hoc* war-time problems.

At the end of the war, a new programme of experimental work in crop husbandry was drawn up by Hanley and Hudson and subsequently expanded with the help of W. J. Ridgman, M. G. Barker, J. D. Whitear and R. H. Jarvis. In view of the large area of heavy clay soils in eastern England and the high proportion of heavy gault clay land on the University Farm, it was decided to give special attention to two main problems (a) the use of leys in the maintenance of soil fertility and (b) a detailed study of lucerne and lucerne-grass leys.

Two long-term experiments have been established to investigate the effects of length of ley, type of ley and management of ley on yield and quality of the succeeding arable crops in 2 different rotations. One of these experiments, on heavy gault clay, compares lucerne-cocksfoot leys with ryegrass-S.100 leys, both as 3-year leys and as 6-year leys, each being followed by 3 and 6 years of arable cropping. Also mowing is compared with grazing in all combinations with these treatments. The other long-term experiment is on light gravel land and compares 1-year, 2-year and 3-year leys in a 6-course rotation. Lucerne alone, lucerne-cocksfoot mixture and cocksfoot alone are 3 types of 3-year and 2-year leys being compared ; the 1-year leys are broad red clover alone and Italian ryegrass alone. To obtain certain fundamental information, 3 levels of nitrogenous fertiliser applied to all crops and 2 levels of farmyard manure applied to the first indicator crop are also included.

The study of lucerne and lucerne-grass leys includes investigating the effect of (a) variety of lucerne and strain of grass on the yield and botanical composition of a lucerne-grass ley (51) ; (b) different times of applying sulphate of ammonia to an established lucerne-cocksfoot ley (52) ; (c) a wide range of different spacings of plants of lucerne when grown alone ; (d) lucerne and cocksfoot sown separately in alternate rows as compared with lucerne and cocksfoot sown together in the same rows ; in both cases several row spacings and levels of application of nitrogenous fertiliser are tested, as well as 2 varieties of lucerne ; (e) various cutting treatments, including height of cutting, time, frequency and stage of growth of cutting on both lucerne alone

and lucerne-cocksfoot grown together ; (f) date of defoliation on the subsequent growth of a lucerne-cocksfoot ley, using a wide range of dates ; (g) summer and autumn management of lucerne-cocksfoot mixtures, including a comparison of mowing and grazing, both in the summer and at 2 different times in the autumn (53); a wide range of autumn defoliation dates, each following 5 different programmes of summer defoliation, are also compared on leys of different ages ; (h) time of defoliation of foggage on a lucerne-cocksfoot ley covering the whole winter period from October to March.

Other experiments on the effect of leys on succeeding crops have studied the effect of different ways of dealing with the aftermath of broad red clover on the yield of the following crop. Bastard fallowing, grazing by sheep, mowing for hay, ploughing in and taking a seed crop have all been tried in conjunction with top dressings of nitrogen. One of the most important factors seemed to be associated with the quality of the seed bed obtained for the wheat crop and experiments are now in progress on the University Farm to test the effect of different dates of ploughing the clover aftermath, combined with several sowing dates and several nitrogen treatments.

Following up the earlier work on fertiliser placement, long-term experiments testing the effect of combine drilling seed and fertiliser for all crops as compared with broadcasting the fertiliser and drilling the seed separately were started on the University Farm and on a light chalkland farm near Cambridge. The University Farm experiment, which was restricted to phosphate fertilisers, has provided no useful information, since the initial high phosphate status of the field prevented any response to phosphate applied by any method for several years but the other experiment is beginning to provide interesting results.

Field and laboratory studies by Ridgman on blackgrass (*Alopecurus agrestis*), one of the worst weeds on heavy land in the Eastern Counties, have been in progress for some time in an attempt to find better methods of control.

At the outset, crop husbandry experimentation at Cambridge sought to measure the crop and grass yield increases obtainable from simple fertiliser treatments and to compare crop varieties and grass mixtures. The next stage was analytical interpretation of yield differences of various crops in terms of plant populations and stages of plant development. To this has finally been added the yield study of crops and grass in rotations. Interpretation of these rotational effects, by soil studies, will involve prolonged chemical, physical and microbiological investigations on which a modest start has been made in the School of Agriculture.

Bibliography

(1) Mem. Camb. Sch. Agric. 1950, **21.**

(2) *2nd Annu. Rep. Field Experiments, Dep. Agric., Cambridge* 1899–1900.

(3) *5th Annu. Rep. Experiments with Crops and Stock, Dep. Agric., Cambridge* 1902–1903.

(4) Middleton, T. H. *J. Agric. Sci.* 1905, **1,** 122.

(5) *4th Annu. Rep. Experiments with Crops and Stock, Dept. Agric., Cambridge* 1901–1902.

(6) Armstrong, S. F. *J. Agric. Sci.* 1907, **2,** 283.

(7) Amos, A. & Woodman, H. E. *J. Agric. Sci.* 1922, **12,** 337.

(8) Woodman, H. E. & Amos, A. *J. Agric. Sci.* 1924, **14,** 99.

(9) Amos, A. & Woodman, H. E. *J. Agric. Sci.* 1923, **13,** 163.

(10) Woodman, H. E. & Amos, A. *J. Agric. Sci.* 1926, **16,** 406.

(11) — — *J. Agric. Sci.* 1924, **14,** 461.

(12) — — *J. Agric. Sci.* 1928, **18,** 194.

(13) — — *J. Agric. Sci.* 1926, **16,** 539.

(14) Amos, A. & Woodman, H. E. *J. Agric. Sci.* 1925, **15,** 444.

(15) Woodman, H. E. & Hanley, F. *J. Agric. Sci.* 1926, **16,** 24.

(16) Amos, A. & Williams, G. *J. Agric. Sci.* 1922, **12,** 323.

(17) Amos, A. *J. Minist. Agric.* 1926, **33,** 26.

(18) Wood, T. B. & Stratton, F. J. M. *J. Agric. Sci.* 1910, **3,** 417.

(19) Hanley, F. Report privately printed, 1927/1928.

(20) Hanley, F. & Woodman, R. M. *J. Soc. Chem. Ind.* 1930, **49,** 215.

(21) Garner, F. H. & Sanders, H. G. *J. Agric. Sci.* 1932, **22,** 551.

(22) Hanley, F. *J. Minist. Agric.* 1934, **41,** 21.

(23) Garner, F. H. & Sanders, H. G. *J. Agric. Sci.* 1936, **26,** 415.

(24) — — *J. Agric. Sci.* 1937, **27,** 447.

(25) — — *J. Agric. Sci.* 1938, **28,** 401.

(26) Culpin, C. *J. Agric. Sci.* 1936, **26,** 22.

(27) — *J. Agric. Sci.* 1936, **26,** 45.

(28) — *J. Agric. Sci.* 1937, **27,** 432.

(29) Garner, F. H. & Sanders, H. G. *J. Agric. Sci.* 1935, **25,** 361.

(30) Doughty, L. R., Engledow, F. L. & Sansom T. K. *J. Agric. Sci.* 1929, **19,** 472.

(31) Engledow, F. L. *J. Agric. Sci.* 1925, **15,** 125.

(32) — *J. Agric. Sci.* 1926, **16,** 166.

(33) —— *J. Agric. Sci.* 1928, **18,** 1.

(34) Garner, F. H. & Sanders, H. G. *J. Agric. Sci.* 1936, **26,** 316.

(35) Hudson, H. G. *J. Agric. Sci.* 1939, **29,** 76.

(36) — *J. Agric. Sci.* 1941, **31,** 116.

(37) — *J. Agric. Sci.* 1941, **31,** 138.

(38) Engledow. F. L. *J. Agric. Sci.* 1928, **18,** 574.

(39) Garner, F. H. & Sanders, H. G. *J. Agric. Sci.* 1939, **29,** 48.

(40) — — *J. Agric. Sci.* 1939, **29,** 58.

(41) Hey, G. B. & Kemsley, W. F. F. *J. Agric.* Sci. 1939, **29,** 69.

(42) Garner, F. H. & Sanders, H. G. *J. Minist. Agric.* 1939, **45,** 1198.

(43) Hanley, F. *Agric. Prog.* 1932, **9,** 64.

(44) Garner, F. H. & Sanders, H. G. *J. Agric. Sci.*1940, **30,** 182.

(45) — — *J. Agric. Sci.* 1939, **29,** 164.

(46) Hanley, F. & Mann, J. C. *J. Minist. Agric.* 1936, **43,** 15.

(47) Hanley, F. *J. Minist. Agric.* 1938, **45,** 671.

(48) Hanley, F. & Tunnington, F. *Emp. J. Exp. Agric.* 1936, **4,** 379.

(49) Hanley, F. & Ridgman, W. J. (*In the Press*).

(50) McMillan, J. A. & Hanley, F. *J. Minist. Agric.* 1936, **42,** 1205.

(51) Ridgman, W. J., Hanley, F. & Barker, M. G. (*In the Press*).

(52) Ridgman, W. J., Hanley, F. & Barker, M. G. *J. Agri. Sci.* 1955, **46,** 441.

(53) Barker, M. G., Hanley, F. & Ridgman, W. J. *J. Agric. Sci.* 1955, **46,** 362.

** Limited reprints available for free distribution. Please quote marginal number instead of full title. Enquiries for papers not numbered should be sent to the author.*

AGRICULTURAL ECONOMICS

Chicory Growing in the Fens. Pp. 12.
Fm Econ. Br. Mimeogr. Rep. No. 50, 1954. Price 1s. 6d. Post Free.

The cost of growing chicory in and around the fens in 1952 was found to be just over £50 per acre—little different from the cost of producing sugar beet, which in many ways it closely resembles. Since yields in this year were rather low, the price paid per ton, £5 5 0, left the average grower with only a small margin of profit per acre—particularly when compared with sugar beet. It is however a useful crop to grow, for it fits anywhere in the rotation, does not " draw " the land, thrives in soils unsuitable for cereals or sugar beet, and, in particular, is not subject to eelworm.

Interpretation of Farm Accounts. Pp. 28.
Fm Econ. Br. Fmr's Bull. No. 18, 1955. Price 2s. Post Free.

A bulletin under this title was first issued in 1932. Recent advances in the technique of farm analysis have rendered a revision of this publication necessary. Methods of assessing the economic efficiency of a farm are demonstrated. The key factors are net output and a number of input-output ratios, including output in relation to the use of labour and machinery, and livestock output in relation to the use of feeding-stuffs. A systematic method of analysis was illustrated by an example which showed how weakness in management could be traced by the use of such tests.

Profitable Egg Production. Pp. 25.
Fm Econ. Br. Fmr's Bull. No. 17. 1954. Price 2s. 6d. Post Free.

This bulletin summarises the results of a two year investigation of the economics of egg production. The flocks were divided into battery, deep litter, hen yard and free range. An attempt was made to summarise the implications on profitability of variations in :—

(*a*) yields and feeding policy ;
(*b*) date of hatching and date of culling ;
(*c*) systems of management and use of labour.

Report on Farming—1953. Pp. 36.
Fm Econ. Br. Rep. No. 42. 1955. Price 4s. Post Free.

This report gives the results of a survey of approximately 400 farms in the Eastern Counties of England. Comparision with the results from previous surveys dating from 1931 show that, over this period, farm income has shown three distinct phases. From 1931 to 1939 farm profits were low. From 1939 to 1942 there was a sharp increase in farm income which rose much more rapidly than the cost of living. From 1943 to 1953, farm income fluctuated, but over the period, increases in profits kept more or less in step with the rise in the cost of living. Government policy has, therefore, succeeded in maintaining the real income of farmers over this period.

In previous reports, analysis of farms has been by district only. In this report farms were also classified by types. The most profitable were the Fen farms and the mixed arable farms with pigs and poultry. The least profitable were the mixed cropping farms with vegetables. This latter group had an unfortunate year in 1953, due mainly to low prices. On the whole farms with a high output had the largest farm incomes, but also required substantially greater amounts of working capital.

On the whole, profits in 1953 were at record levels and averaged £1652 per farm (average size 164 acres) compared with £1350 in 1952. Crop yields were excellent in 1953 due to favourable weather conditions. Costs continued to rise, but at a less rapid rate than in previous years.

Results of a Survey into the Costs and Returns from Producing Wheat and Barley on 120 Farms in the Eastern Counties, 1953. Pp. 6.
Fm Econ. Br. (*Mimeogr.*)

A preliminary report on a random sample of 120 farms.

RICHARDS, R. D. & JORDAN, P.
Groundwork of Economics. 7th ed. Revised by R. A. Mackness. Pp. 339.
(*Univ. Tutorial Press, London*, 1954. 7s. 6d.).

1280* WHETHAM, E. H.
The Agricultural Expansion Programme, 1947–51.
J. Agric. Econ. 1955, **11**, 313–9.

An account of the objects and results of the expansion programme launched in 1947.

WHETHAM, E. H.
A Record of Agricultural Policy, 1952–1954. Pp. 23.
Fm Econ. Br. Occ. Pap. No. 2. 1955. 2s. Post Free.

This publication continues for a further two years the record of agricultural policy, administration and statistics begun in 1952.

WHETHAM, E. H.

The Theory of Rent in Practice.

Fm Econ. 1954, **7**, 434–5.

A brief discussion on the treatment of rent in the annual agricultural price review under the Agricultural Act, 1947.

OTHER PAPERS

BARNARD, C. S. **Milk and Money.** *Spillers Livestock Mag.* 1955 (59), 14–17.
BARNARD, C. S. **Some Financial Aspects of Feeding the Dairy Herd.** *Guernsey Breed. J.* 1955, **9** (2), 33–5.
CLARKE, G. B. **Pig Recording Pays.** *Agriculture, Lond.* 1955, **62**, 91–2.
1225* CLARKE, G. B. **Solving the Prices Problem.** *Pig Fmg.* 1954, **2** (11), 35–6.
CLARKE, G. B. **This Pigonometry.** *Pig Fmg.* 1954, **2** (12), 30.
MACKNESS, R. A. **Economics of Grass Drying.** *Yearb. Ass. Green Crop Driers.* 1954, 11–13.
MACKNESS, R. A. **Economics of Meat Production.** *Hereford Agric. J.* 1955, **14** (Spring), 39–51.
NIX, J. S. **Buying a Beet Harvester.** *Fm Mech.* 1955, **7** (76), 342–3.
NIX, J. S. & ATTWOOD, E. A. **Economics of the Combine Harvester.** *Power Fmr.* 1954, **13**, 159–60, 190, 192, 214–5, 217.
STURROCK, F. G. **Assessing Tractor Requirements.** *Fm Mech.* 1955, **7** (77), 368–70.
STURROCK, F. G. **Is it Justified ? Investment in New Machinery.** *Esso Fmr.* 1955, **7** (3), 8–10.
WALLACE, D.B. **Problems Faced in the Eastern Counties.** *Times Agric. Rev.* 1955 (12), 3, 5.

AGRICULTURE

ENGLEDOW, F. L., *et al.*

Report of the Commission of Enquiry on the Scientific Department, Indian Tea Association. Pp. 162 with 4 Diagrams and 2 Plates.

London and Calcutta, 1954.

Questionnaires were sent out to estates and agency houses and visits were paid to estates and the Research Station at Tocklai, Assam.

Enquiry shows the imperitiveness of reducing production costs with no lowering of quality. For research and advisory purposes closer definition of the soil-climate regions of the tea areas is essential.

After reviewing the problem of tea growing, the sections of research are discussed in turn.

The largest and most inscrutable soil problem is fertility maintenance, particularly where heavy crops of tea have been grown for a great number of years and re-planting with new genetic types is contemplated. Protection against drought in some areas by mulching and special pruning methods is recommended for immediate investigation. Though in drainage and soil erosion considerable basic knowledge is available, it is not considered that this has been as widely and effectively applied as is desirable.

Great progress has been made in developing new types (clones) and there has also been considerable headway with the inter-pollination of clones (two, three or four at a time) for the purpose of producing seed to supply bushes for re-planting. It is recognised that many questions have yet to be solved in the handling of clones, including the use of single clones against inter-clonal hybrids. Part of the complexity of these questions arises from the great importance of quality in tea.

Most tea in N.E. India is grown under shade, and although field trials have given a better understanding of the spacing, shade species and other aspects, fundamental knowledge of the obviously complex influences of shade trees is now considered to be indispensable.

In tea manufacture, all stages from the green leaf to the made tea are examined, special attention being given to the newly launched investigations on the possibility of devising new machinery and even converting the present separate processes into a continuous, fully mechanised operation. This possibility adds yet further importance to the understanding of the ultimate basis of tea quality, for further work on which special recommendations are made.

Soil and rainfall maps of the tea areas of N.E. India are given and graphs showing yield and labour requirements an acre over a long period of years. The work of the Station in all sections during the past twenty years is fully described in an Appendix.

HANLEY, F.

Agriculture of the Sand Lands. Pp. vi + 49.

Bull. Minist. Agric., Lond. No. 163, 1954. (H.M. Stat. Office, 2s. 6d.).

The farming of light sand lands in some parts of the country has been profoundly changed in recent years by the introduction or extension of root crops like sugar beet and carrots ; by the realisation that lucerne leys or lucerne grass mixtures can be relied upon to provide keep for stock even in dry years, thereby making possible important livestock enterprises including winter milk production ; by the lowering of costs by mechanisation ; and by increased yields of cereals through the use of better standing varieties and heavier applications of nitrogenous fertilisers.

Wider appreciation of the possibilities arising from these changes is of great national importance for there are still large areas of sand land where production is low and many acres remain uncultivated.

The main object of this survey was to examine and describe the agricultural circumstances and farming systems of the sand land areas in districts with a rainfall of less than 30 inches a year, paying special attention to the chief problems and difficulties encountered in the different areas.

The report is restricted to matters of a scientific and technical nature as distinct from economic problems.

1244* Cock, A. G.

Half-and-half Mosaics in the Fowl.

J. Genet. 1955, **53**, 49–80.

A half-and-half mosaic pullet (case N) from the cross Rhode Island Red ♂ × Light Sussex ♀ is described. The right side of the bird shows all the characters to be expected in a pullet from this cross. The left side is abnormal in the following ways :—

(*a*) The shank is yellow instead of white.
(*b*) The plumage is a darker shade of reddish brown.
(*c*) The feathers, especially the flight feathers of the wing, have a frayed appearance, due to imperfectly formed barbules.
(*d*) The whole of the left side of the body is very much smaller than the right, and the limb bones, in particular, are abnormally proportioned.

Two females are described which are asymmetrical only in respect of the length of the legs. One of these had originally been regarded as a mosaic, but it now appears that in both cases a copper ring accidentally left too long on the right shank of the young chick has been the cause of hypertrophy of the right tarsometatarsus and tibiotarsus.

The twenty-three known half-and-half mosaic fowls are discussed in relation to the theory of Crew & Munro, which postulates that all such cases are due either to elimination, or to non-disjunction, of a single autosome at first cleavage. The following objections to this theory are pointed out :—

(*a*) The data available on the proportions of the limb bones in several cases are inconsistent with the requirements of the theory.
(*b*) At least five cases, and probably six, are mosaic in respect of a sex-linked character.
(*c*) Three cases are mosaic in respect of more than one autosomally inherited character (apart from size). In no case do linkage data support the idea that the genes concerned are all situated on the same chromosome, and it is unlikely that this could be true in all cases.
(*d*) The theory requires unsupported assumptions about the dosage relations between alleles at two loci.
(*e*) The theory assumes that an extra autosome above the normal diploid number will tend to swing the sex in a male direction ; this is the reverse of what is to be expected on the sex-chromosome : autosome balance theory of sex determination.

An attempt is made to find plausible and consistent explanations for as many as possible of the known cases. These are clearly due to a diversity of causes, and fall into two main types :

(*a*) Those in which somatic segregation has occurred at first cleavage in an otherwise normal zygote. In some, the somatic segregation has taken the form of maldistribution (elimination or non-disjunction) of a single pair of autosomes, or possibly of somatic crossing-over. Simple somatic gene-mutation may account for a few cases. In others (gynandromorphs) elimination of an X-chromosome has occurred. In yet others, multiple irregularities in the distribution of the autosomes seem to have occurred; to this cause are assigned only those cases (of which N is one) which cannot be satisfactorily explained in any other way.
(*b*) Those originating from a compound zygote ; more specifically, in which one side of the body is of purely paternal origin (and diploid), the other side being of normal bisexual origin. This may, or may not, lead to gynandromorphism.

The explanations suggested for individual mosaics are all open to some degree of doubt. Certain other difficulties remain, notably the absence of any gynandromorphs genetically female on the right side. There is also some difficulty in reconciling the irregular type of mosaic found in some species of bird (pigeon, turkey) with the bilateral half-and-half characteristic of other species (fowl, finches).

1229* Cock, A. G.

A Note on J. S. S. Blyth's Mosaic Hen.

Poult. Sci. 1954, **33**, 1034–6.

The probable mode of origin of a half-and-half mosaic hen reported by Blyth is discussed. It is shown that the known facts about the bird and her progeny are very difficult to reconcile with the explanation offered by Blyth. They are, however, reasonably consistent with another explanation : namely, that the two halves of the mosaic are derived from two distinct maternal nuclei (one possibly a polar body) each fertilised by a separate sperm.

Cock, A. G.

Segregation within Inbred Lines of Chicken (*Abstract*).

Heredity. 1955, **9**, 291.

By examining F_1 crosses in this country and in U.S.A., hypostatic colour factors carried by inbred lines of two white breeds have been identified. In White Plymouth Rocks (recessive white) 11 out of 16 lines are segregating at the **E**-locus, and 6 out of 16 at the **S**-locus (sex-linked). In White Leghorns (dominant white) 6 out of 12 lines are segregating at the **E**-locus and 3 out of 7 at the **Bl**-locus. The coefficients of inbreeding of the lines vary from 37.5 to 98.7%. The amount of segregation occurring is greater than could reasonably be expected in the absence of selection favouring heterozygotes. A comparison is made with similar results relating to blood-group loci obtained by other workers.

GILMOUR, D. G.

Selective Advantage of Heterozygosis for Blood Group Genes among Inbred Chickens. (*Abstract*) *Heredity*. 1954, **8**, 291.

In a line of White Leghorn chickens which has been maintained by brother-sister matings for fifteen generations, segregation is still occurring at three independent loci determining antigens of the red blood cells. Approximately 50% heterozygosis for each locus occurs in each generation.

Artificial selection has involved the retention as breeders of individuals from the largest sib-groups in each year. In this selection individuals with three or two blood group loci heterozygous have an advantage over those with one or no heterozygous loci. This is shown in two ways. Firstly, the more heterozygous dams produce significantly larger families surviving to maturity. Secondly, in most families the more heterozygous individuals survive in excess of the expected Mendelian proportions.

HUNTER, G. L.

Size of Border Leicester and Welsh Mountain Sheep Compared with their Reciprocal Crosses. *Proc. Brit. Soc. Anim. Prod.* 1954, 63.

An experiment, designed to determine the extent of the maternal influence on size in sheep, in which groups of Border Leicester and Welsh Mountain ewes were bred to rams of both breeds, has shown that the nature of the maternal environment had a relatively small effect on the size of lambs at birth and on their subsequent growth. The maternal influence on a late maturing character (liveweight) was larger than on an early-maturing character ('cannon-bone' length), but the effect of heterosis on the late-maturing character was greater still and tended to overshadow the maternal effect.

The method of ascertaining the relative importance of various factors in determining body size at any particular age has been suggested as an aid to selection.

The experiment was continued in the autumn of 1953. The reciprocal crosses were repeated and eighteen attempts at ovum transplantation were made. The results of these are not yet available, but a more detailed and, therefore, more critical analysis is anticipated.

1223* JOUBERT, D. M. & HAMMOND, J.

Maternal effect on Birth Weight in South Devon × Dexter Cattle Crosses. *Nature, Lond.* 1954, **174**, 647–8.

A preliminary account of reciprocal crosses. While pure South Devon calves weigh 94 lbs. and Dexters 52 lbs. at birth, three crossbred calves out of South Devon dams averaged 72 lbs. and three crossbred calves out of Dexter dams averaged 57 lbs. at birth. The weight of the placenta expressed as a percentage of the birth weight of the calf averaged 14.5% for the large and 7.1% for the small reciprocal crosses.

1279* PEASE, M. S.

Unexpected Black Chicks. *Autosex. Annu.* 1955, 13–16.

Another case is described which does not fit in with the usually accepted account of the inheritance of Black, Columbian, and Black-Red plumage patterns in poultry.

OTHER PAPERS

HAMMOND, J. **Breeding of Dual Purpose Cattle.** *Dairy Shorth. J.* 1954, **23**, 577.

HAMMOND, J. **Lecture on Cattle Breeding.** English Guernsey Cattle Soc., 20 October, 1954. Pp. 12.

ANIMAL NUTRITION

1258* BRAUDE, R., CAMPBELL, R. C., LUCAS, I. A. M., *and others.*

Antibiotics and Endocrine Stimulants as Promoters of Growth in Fattening Pigs. *Brit. J. Nutrit.* 1955, **9**, 191–6.

A co-ordinated experiment involving 154 pigs in five centres was carried out in order to establish whether the growth-promoting effect associated with feeding of an antibiotic with a normal fattening diet was enhanced when the antibiotic was supplemented with L-thyroxine alone or with stilboestrol.

Marked variation in response to a given treatment was recorded at the different centres. In one of the centres toxic signs were observed, apparently associated with the feeding of stilboestrol, and the advisability of using the substance for promoting growth is thus open to doubt. In two out of three centres a significant growth response was obtained by adding L-thyroxine to diets containing an antibiotic.

BROOKES, A. J.

Problems Associated with the Store and Fattening Periods. *Brit. Vet. Ass. Publ.* No. 24, 1955, 80–88.

The main conclusions which may be drawn from the Cambridge beef production experiments as regards levels of rearing beef calves are summarised. Points of management of store cattle discussed include summer treatment of autumn-born calves, dosing for worms and treatment of ringworm, and wintering of store cattle. Husbandry problems arising in grass fattening of cattle are briefly discussed.

1286* Halley, R. J.†

Certain Pasture Variations and their Effect upon the Dairy Cow.

J. Brit. Grassl. Soc. 1955, **10**, 229–39.

During the years 1950, 1951 and 1952 a series of experiments was conducted to study the effect of providing dairy cattle with pasture herbage at different stages of maturity. The differences between the herbage treatments were measured by recording the weights of wet and dry herbage present on given areas and the chemical composition of the herbage dry matter.

The effect of the herbage treatments upon the cows was measured by recording grazing behaviour, herbage consumption, milk yields and milk quality.

A satisfactory method for measuring herbage consumption was not devised and it was suggested that an understanding of the reaction of dairy cattle to pasture variation depends upon the development of such a technique.

The time cows spend grazing and lying down was shown to vary with the maturity of the herbage grazed.

In two of the five experiments, milk yields varied significantly with the maturity of the herbage grazed.

The experiments failed to relate fat and solids-not-fat content of milk to the maturity of the herbage grazed.

†Work carried out at the Seale-Hayne Agricultural College.

Halnan, E. T., Moskovits, I. & Threlkeld, T. (Editors).

Problems of Animal Feeding in Europe. Pp. 147.

FAO Agric. Dev. Pap. No. 51, 1955. 7s. 6d.

1266* Harrington, G. & Taylor, J. H.

Effect of Antibiotic Dietary Supplements on the Carcass Measurements and Dressing Percentage of Bacon Pigs.

J. Agric. Sci. 1955, **46**, 173–9.

Certain carcass measurements (length, shoulder and mid-back fat thickness, and dressing percentage) made on a total of 402 bacon pigs from four antibiotic feeding trials carried out mainly at the Agricultural Research Council's Field Station at Compton, were analysed. The most interesting points that emerged from these analyses, involved comparisons between the effects of the two antibiotics, aureomycin and penicillin, rather than between the controls and the average of the antibiotic treatments.

The length of the carcasses showed more variation between pens treated with various doses of penicillin than between control pens or pens treated with aureomycin. This greater variation in length was related to the greater variation in growth rate between the penicillin treatments. No differences in the mean lengths of control, penicillin and aureomycin treatments were found.

Back fat measurements and belly thickness showed no differences between aureomycin, penicillin and control treatments in overall tests.

Aureomycin consistently gave higher dressing percentages than penicillin. It was also found that the "animal protein" diet gave higher dressing percentages than the "vegetable protein" diet in the one experiment in which this comparison was made.

1252* Taylor, J. H. & Harrington, G.

Influence of Dietary Antibiotic Supplements on the Visceral Weights of Pigs.

Nature, Lond. 1955, **175**, 643–4.

The average weights of the stomach, small intestine, caecum, large intestine, liver and spleen of the control, aureomycin and penicillin groups of Large White pigs used in an antibiotic feeding trial are given, together with the levels of significance of the differences between them. The total weight of the organs considered was considerably greater in the penicillin-fed animals than in those fed with aureomycin and this may partially explain the significantly greater dressing percentage (reported elsewhere) of aureomycin-fed animals compared with penicillin-fed animals in this experiment and two others.

OTHER PAPERS

BROOKES, A. J. **Rearing Calves and Young Cattle.** *Spillers Livestock Mag.* 1955 (60), 14–17, 20.

BROOKES, A. J. **Rearing Calves to Beef.** *Inst. Meat Bull.* 1955 (11), 18–22.

1230* HALNAN, E. T. **Impact of Research on Practical Poultry Feeding.** *Yearb. Poult. Ass. G.B.* 1955, 21–6.

ANIMAL PATHOLOGY

1274* Campbell, R. C. *and others.*

Virus Pneumonia in Pigs.

Vet. Rec. 1955, **67**, 661–5.

Eight experiments involving 120 pigs were undertaken to determine the effect of experimentally induced virus pneumonia on the growth-rate and the efficiency of feed utilisation of bacon pigs. The experiments covered the period from weaning to bacon weight and the pigs were kept under a variety of conditions.

In these experiments virus pneumonia was found to depress the growth-rate by 16% and the food conversion efficiency by 22%. The effect of the disease in the field is thought to be at least as great as this.

1270* Averill, R. L. W., Adams, C. E. & Rowson, L. E. A.
Transfer of Mammalian Ova between Species.
Nature, Lond. 1955, **176,** 167.

Sheep eggs were obtained from the Fallopian tubes of ewes treated with P.M.S. and mated 2½ to 3 days prior to recovery. Eggs in the 2 to 12-cell stage were transferred to the Fallopian tubes of rabbit does which had been mated with a vasectomised buck 2 to 114 hours previously. Four to five days later the rabbits were killed and the eggs recovered from the uterus (4 cases) or tubes (1 case). Whereas the rabbit eggs were found uncleaved the sheep eggs had continued to cleave normally ; there were six 32-cell morulae, two 6-days blastocysts and one 8-day blastocyst. The sheep eggs had acquired the mucin layer characteristic of the rabbit egg. Two 6-day blastocysts were re-transferred to a non-pregnant ewe 6 days after heat and when this animal was killed 16 days later two normal embryos were found. The use of the reproductive tract of the rabbit as an incubator may enable the successful long-distance transport of sheep eggs.

1261* Campbell, R. C. & Edwards, J.
Effect of Conception Rates of Semen Diluents containing Citrate or Phosphate Buffer, with all Combinations of Sulphanilamide, Streptomycin and Penicillin.
J. Agric. Sci. 1955, **46,** 44–55.

A 24 factorial experiment involving 68,713 first inseminations was carried out at four artificial insemination centres, to compare semen diluents containing citrate or phosphate buffers and all combinations of sulphanilamide, streptomycin and penicillin.

The analysis of the results was carried out on punched card machines and on an automatic calculator (EDSAC), as well as on bench machines.

The main results obtained were :—

(*a*) Unsupplemented phosphate buffer gave a conception rate 5.5% above that obtained with unsupplemented citrate buffer.
(*b*) Citrate buffer with sulphanilamide, streptomycin and penicillin gave a conception rate 6.8% above that obtained with unsupplemented citrate buffer ; and
(*c*) Phosphate buffer with penicillin gave a conception rate 9.3% above that obtained with unsupplemented citrate buffer. This effect was not, however, significantly greater than that referred to in (*b*).

Hammond, J.
Deposition of Fat in Farm Animals.
Contr. to a *Symposium on Obesity. Adv. Sci.* 1955, **12,** 126–7.

A short account of the order of development of the different tissues in the body and how this affects the amount of fat produced on different planes of nutrition by the fact that early maturing tissues have priority of supply of nutrients in the blood stream.

Hammond, J.
The Effects of Climate on Reproduction.
Contr. to *Breeding Beef Cattle for Unfavourable Environments.* Pp. 31–9. Ed. by A. L. Rhoad. Univ. Texas Press, 1955. $4.75.

A summarised account of factors affecting reproduction in farm animals considered under the following headings—Darkness—Daylight hours ; Air Temperatures ; and Humidity.

Hammond, J.
La Fonction Tubaire chez les Animaux Domestiques.
Contr. to *La Fonction Tubaire,* pp. 16–21, 1955. Masson, Paris.

The functions of the various parts are described. The *fimbriated end* in the fowl becomes intensively active at the time of ovulation and grasps the egg, but fails to grasp more than one in multiple ovulations. In cattle and sheep there is accommodation for many more eggs than normally ovulate but where the number of eggs is very excessive the large accumulation of liquor folliculi prevents the fimbria collecting all the eggs. This is particularly marked in prepubertal animals where the quick development of the ovary far outstrips the development of the tube. The *muscle layers* react to hormones like the uterine muscle ; upward movement of the sperm is probably caused by contraction due to oxytocin liberated as the result of coitus. Oestrogen contracts and progesterone dilates the tube so that the passage of the egg down the tube is speeded up by progesterone, ciliary action then having full play. The *ciliated cells* create a downward current of fluid in which the eggs move. The *albumen cells* which produce the white of the egg in the fowl provide an albumen layer for the egg of the rabbit, but not for those of the cow and ewe.

1260* Hammond, J.
Hormones in Relation to Fertility in Farm Animals.
Brit. Med. Bull. 1955, **11,** 165–8.

A summarised account with references to the literature under the following headings. Hormone balance ; increasing the ovulation rate ; breeding during the non-breeding season ; speeding up the age of puberty ; effects of nutrition on hormone action ; transplantation of fertilised ova ; hormones and uterine infection ; and effects on the male.

HAMMOND, J. (*Editor*).
Progress in the Physiology of Farm Animals.
Vol. 2. Pp. 393–740 + xv. (Butterworths Sci. Publ., London, 1955. 45s.).

This volume contains chapters on Live-weight Growth ; Conformation and Body Composition ; Wool Growth ; Behaviour of Grazing Animals ; Sexual Behaviour ; Mechanism of Movement ; and Egg Production and Fertility in Poultry.

1246* HAMMOND, J.
Quality in Meat Production.
J. Yorks Agric. Soc. 1955, **106,** 19–32.

The main requirements, including weight, in a good carcass of beef and lamb are described. Methods of breeding and feeding for suitable carcasses from dairy cows, a " points " system of judging lamb carcasses, and the effects of different systems of feeding on conformation and quality are described.

1251* HARRINGTON, G. & POMEROY, R. W.
An Analysis of Carcass Measurements of Post-War British Bacon Pigs.
J. Agric. Sci. 1955, **45,** 431–51.

Measurements made on smoked sides of bacon exhibited since the war at N.P.B.A. carcass competitions at Stirling and Peterborough have been analysed to investigate differences between the shows, the years and the sexes. In the Large White exhibits, the sides from gilts were, on the average, longer, thicker on the belly, thinner in back fat and had better developed eye muscles than the sides from hogs. The area of eye muscle of the carcasses entered in the shows between 1948 and 1952 shows an unexplained decrease over this period. The width of the eye muscle is the only character showing a definite show difference, being larger at Stirling than at Peterborough. The carcasses entered in the shows between 1947 and 1953 show improvements over those entered between 1932 and 1937 in all respects except for eye muscle measurements.

A selection of Danish No. 1 sides of bacon were longer, lighter in the fore-end, less deep and slightly thicker in the belly than some Large White show carcasses, but there was little difference in back fat measurements. A selection of Dutch and Danish commercial sides of bacon were very similar in length and fore-end weight, although the Danish sides were a little heavier in the middles. A sample of British commercial sides was inferior to both the Danish and the Dutch in several respects (length and lightness of fore-end), and some Polish commercial sides were worse still in these respects. In these comparisons the effects of different average total side weights were allowed for.

The correlations between the various measurements on the Large White show carcasses, which agree satisfactorily with values previously reported for other breeds, show that most of the measurements are affected by the length and weight of the side.

1263* HUNTER, G. L., ADAMS, C. E. & ROWSON, L. E. A.
Inter-breed Ovum Transfer in Sheep.
J. Agric. Sci. 1955, **46,** 143–9.

Fertilised ova have been transferred from Border Leicester to Welsh Mountain ewes, and vice versa. The oestrous cycles of the ewes were synchronised by progesterone treatment, and donor ewes were superovulated with PMS. 68–90 hrs. after the onset of oestrus in the donors; thirty-seven ova, representing 58% of the ovulations, were recovered *in vivo* from thirteen ewes. Nineteen ova were transferred to eighteen recipient ewes and a total of eight pure-bred lambs were born to ewes of the opposite breed.

Transfers resulted in pregnancy when oestrus in the recipients commenced from 16 hrs. before to 20 hrs. after that in the donors ; two of the ova which developed to term were 4-cell, five were 8-cell and one was a 16-cell ovum at the time of transfer. Four out of seven and four out of eleven transfers, using blood serum and Ringer's solution respectively, resulted in the birth of lambs. Prior to transfer to the recipients seven of the ova which developed to term were exposed for 30–45 mins. at room temperature, whilst one developed after exposure for 70 mins.

1227* HUNTER, G. L., ADAMS, C. E. & ROWSON, L. E. A.
Successful Inter-breed Transfer of Ova in Sheep.
Nature, Lond. 1954, **174,** 890.

Reciprocal transfer of fertilised ova was made between Border Leicester and Welsh Mountain sheep. Synchronisation of oestrus was obtained by progesterone treatment. Donors were treated with P.M.S. 4 days before oestrus. *In vivo* recovery of the ova from the Fallopian tube was carried out by flushing with homologous blood serum or Ringer's solution. Ova were inserted into the lumen of the utero-tubal junction. Three Border Leicester lambs were born to Welsh ewes and five Welsh lambs to Border Leicester ewes, the average weights at birth being 11.1 and 9.5 lbs. respectively. The average weights of normal Border Leicester lambs are 13.5 and Welsh 8 lbs. Transfers were successful when oestrus in the recipients began 16 hours before to 20 hours after that of the donors. Fifty-eight per cent of the ova shed were recovered from the donors and of the eight successful transfers two were 4-cell, five 8-cell and one 16-cell ova.

1271* JOUBERT, D. M.

Growth of Muscle Fibre in the Foetal Sheep.

Nature, Lond. 1955, **175**, 936–7.

Cross diameters of muscle fibres of foetal sheep of different ages were measured in *M. longissimus dorsi*, *M. rectus femoris* and *M. gastrocnemius*. The muscle fibre undergoes but little change in diameter from a foetal weight of 8 grs. to just over 800 grs., or about 100 days, being about 4.6 μ. Subsequently however, a considerable increase in muscle fibre diameter occurs, corresponding to increase in body weight, and reaches an average of 22.4 μ at birth. Despite the sudden break and increase in the slope of the curve of muscle fibre diameter between 800 and 1200 grs. it is not inferred that muscle cell formation ceases abruptly at that stage.

1232* JOUBERT, D. M.

Influence of High and Low Nutritional Planes on the Oestrous Cycle and the Conception Rate of Heifers.

J. Agric. Sci. 1954, **45**, 164–72.

During the course of investigations on the influence of High- and Low-nutritional planes on the growth, reproduction and production of heifers, sexual activity was studied by recording oestrus data. A total of 239 observations were recorded for fourteen maiden heifers for each nutritional plane ; 161 for the High-plane individuals and 78 for those on the Low plane. The investigation included four breeds, viz. Beef Shorthorn, Afrikaner, Friesian and Jersey.

The average length of the dioestrous cycle was 20.16 days for the High-plane animals, and 20.83 days for their Low-plane counterparts, the difference of 0.67 days not being statistically significant. Breed differences were not very marked, but a tendency was revealed for the Friesians of both planes to have slightly longer cycles on an average than any other breed studied.

The modal length of the cycle for both groups was found to be 19 days, with 95·6% of the cycles falling within the normal range of 17 to 23 days. Cycles exceeding 33 days in length were, however, excluded from these calculations.

A tendency was revealed for the initial post-pubertal cycles to be longer on an average than what is usually considered the normal length. Although the High-plane heifers settled down to a regular rhythm sooner, observations showed that differences existing between individual animals is probably of greater significance in this regard than in any other factor.

Whereas the majority of the High-plane heifers reached puberty during winter, 85·7% of the Low-plane heifers came on heat for the first time in summer. It is suggested that with the approach of favourable nutritional conditions, animals in a low condition first restore depleted body tissues before the sexual cycle returns to normal activity.

A slight tendency was noticed for cycle length to vary with the season in the case of the High-plane animals, longer cycles being recorded in summer than in winter. On the Low-plane, however, the heifers concerned invariably experienced an anoestrous condition during winter, lasting anything up to 218 days. Only after they gained the losses in live weight, was sexual activity restored as previously pointed out.

Sexual activity was shown to be greatest in late summer with little variation over the remainder of the year under normal conditions of nutrition and management, while in the Low-plane individuals it fluctuated from complete inactivity in midwinter to a peak in summer.

Post-partum oestrus was considerably delayed by lactation in the beef animals. The High-plane heifers came on heat only after weaning their calves while the Low-plane individuals required nearly a year in addition to regain depleted body reserves before sexual activity was restored. The Low-plane dairy heifers showed a longer *post-partum* anoestrous period also, the difference between the two groups being 20·77 days.

The results for the number of services required per conception demonstrated that the Low-nutritional plane caused no detrimental influence on this factor. In fact, the difference existing between the two groups studied was in favour of the Low-plane animals. This is in agreement with Asdell's (1952) findings. It was shown that season had no effect on the results obtained.

1241* JOUBERT, D. M.

On the Post-natal Growth and Development of Muscle in Relation to Quality in Meat.

Proc. Brit. Soc. Anim. Prod. 1954, 49–58.

Ten mature Border Leicester × Cheviot ewes were divided into two groups of five, the heavier animals weighing about 150 lb. alive, and the lighter animals approximately 70 lb. The former were placed on a super-maintenance ration. Following successive live weight changes of 20 lb., animals were slaughtered, dissected, and muscle samples taken.

After fixation of the muscle samples in 10% formalin, measurements were recorded of muscle fibre diameter; 50 measurements for each of three muscles (*M. gastrocnemius*, *M. rectus femoris*, and *M. longissimus dorsi*) per animal.

The changes in live weight, carcass weight and total muscular tissue were studied and correlated with the corresponding average muscle fibre diameters. It was shown that a close relationship exists between all those factors, but muscle fibre size was found to be most closely correlated with the total musculature of the carcass.

The relationship between total muscle and average muscle fibre diameter was illustrated by a regression equation. Further proof was provided by the results of more extensive investigations conducted along similar lines.

It was concluded that the development of muscle fibres is essentially a function of an age-weight relationship, and not of chronological age. Within a species, carcasses of the same weight and with an identical muscle-fat ratio, should have muscle fibres of very similar size.

1272* Labban, F. M.
The Effect of Orally Administered L-thyroxine on Fleece Growth in Sheep.
J. Endocrin. 1954, **11,** v.
Ewe lambs were given L-thyroxine administered orally for 11 months, doses ranging from 3–5 mg. weekly. Fleece weights in the grease averaged 8.5 lbs. as compared with 6.3 lbs. for the controls, and as clean wool 5.5 and 4.1 lbs. respectively. The increased weight of wool was not due to increase in fibre thickness and so would appear to be due to length of fibre. It is suggested that thyroxine accelerates the metabolic rate of the follicles and as a result their priority for nutrients becomes high.

1273* Labban, F. M.
Effect of Thyroxine on Sexual Behaviour in the Ewe.
Nature, Lond. 1954, **174,** 933.
After dosage of orally administered L-thyroxine to ewes during the summer, there was at the beginning of the breeding season an intensification of the normal breeding behaviour, the ewes mounting other animals, which is unusual in this species ; the ewes were served and lambed. Ewes during the non-breeding season (April-May) were then fed L-thyroxine but although two ewes jumped other animals they were not served nor were follicles developed in their ovaries.

Maqsood, M.
Effects of the Thyroid Gland on Fleece Growth in Sheep.
Brit. Vet. J. 1955, **111,** 163–9.
The continued oral administration of thyroidal material in suitable doses resulted in a significant increase in the fibre length and wool yield of the treated Suffolk sheep, kept in England. Chemical thyroidectomy produced by the continued administration of thiouracil resulted in a significant decrease in fibre length and wool yield of Suffolk sheep. In both these lines of treatment the difference in the fibre diameters was not significant when compared with the control sheep. How the thyroid gland appears to influence the rate of wool growth is discussed in the light of the previous work.

Pomeroy, R. W.
Live-weight Growth. Pp. 395–429.
Contr. to *Progress in the Physiology of Farm Animals. Vol.* 2. Ed. by J. Hammond. (Butterworths Sci. Publ., London, 1955. 45s.)

1257* Pomeroy, R. W.
Ovulation and the Passage of the Ova through the Fallopian Tubes in the Pig.
J. Agric. Sci. 1955, **45,** 327-30.
The rate of passage of ova down the Fallopian tubes in the pig has been checked on eighteen living sows by laparotomy and in fifteen sows and gilts at autopsy.
Both sets of observations suggest that the ova enter the uterus between 24 and 48 hr. after ovulation instead of 72 hr. as suggested by earlier workers.
It is suggested that the rapid passage of ova through the Fallopian tubes of the pig may be facilitated by the progesterone from the large number of corpora lutea in the ovaries of the pig.

1238* Pomeroy, R. W. & Harrington, G.
Carcass Quality.
Pig Breed. Gaz. 1955 (81), 74–6.
Comparisons of a sample of Danish No. 1 sides of bacon with British Large White show sides, and of other samples of British and Danish commercial sides indicated that the chief points of difference between the British and Danish product, at least as far as conformation was concerned, were in the proportion of fore-end, and the length of side. Comparisons between British pre-war and post-war show sides of bacon showed that improvements had been achieved in external features but not in the important internal measurements such as the depth and width of the eye muscle.

1242* Roy, A. & Rowson, L. E. A.
A Method of Inducing Sterility in the Cow.
Vet. Rec. 1955, **67,** 177–9.
In India where cattle slaughter is discouraged or banned the population has risen beyond food supply so as to endanger production of milk or work. A simple method of causing sterility to check population increase was therefore desirable. After inserting a spring in the cervix with a special apparatus six maiden heifers were run for 6 months with a bull known to be fertile and they were served frequently during that time. Of the oestrus cycles six were normal and nine were of 27 to 39 days duration while there were two cases of 50 to 58 days duration ; this suggested that there was some variation in time when the ovum perished. Four of the heifers were killed within 72 to 96 hours after the onset of the last heat ; one unfertilised egg, one 8-celled, one 12-celled and one degenerating blastocyst were recovered. In another killed 54 days after the last heat was

observed a corpus luteum was found in the ovary but it was not pregnant. The insertion of the spring caused no damage to the morphological condition of the cervix or other parts of the reproductive organs. It was considered possible that entrance of air into the uterus caused sterility, but more possible that continuous mechanical irritation of the cervix and/or uterine endometrium prevented nidation.

OTHER PAPERS

HAMMOND, J. **Adaptation of Farm Animals to their Environment.** *Biol. & Human Affairs.* 1955, **20,** 100–5.
HAMMOND, J. **Beef Production.** *Spillers Livestock Mag.* 1955 (60), 2–3.
1256* HAMMOND, J. **Carcass Quality and the Plane of Nutrition.** *Pig Breed. Gaz.* 1955, **82,** 52–3.
1231* HAMMOND, J. **Essential Steps to Quality in Bacon Production.** *Heath & Fm.* 1954 (9), 329–30.
HAMMOND, J. **Fifty Years from Now.** *Fmr & Stk-Breed.* 1954, **68** (3389), 41.
MANSFIELD, W. S. **Quality Beef Cattle. Choice of Crossing Bulls.** *Times Agric. Rev.* 1954 (11), 11.

CROP PESTS AND DISEASES

1262* COLLING, A. W.
Aphid Chromosomes.
Nature, Lond. 1955, **176,** 207–8.
The biology of the Family *Aphididae* (Greenflies or Aphids) presents many problems concerned with polymorphism, parthenogenesis, speciation, the production of biological races and hybridisation, which are still largely unresolved. An investigation of chromosome numbers and behaviour which should elucidate some of the difficulties at present encountered by workers on this group is being carried out. Methods are discussed, and a few chromosome counts are given.

1254* DICKINSON, S.
Studies in the Physiology of Obligate Parasitism. V. Further Differences between the Uredospore Germ Tubes and Leaf Hyphae of *Puccinia triticina.*
Ann. Bot., N.S. 1955, **19,** 161–71.
A study has been made of the carotin pigment present in the germ-tubes, appressoria, and substomatal vesicles of *Puccinia triticina.* In the germ-tubes this carotin is present in the oxidised condition, while in the spores, appressoria, etc., it is in the reduced condition. The permeability of the germ-tubes, as indicated by range and rate of dye uptake, is less than that of the leaf hyphae. While both germ-tubes and leaf hyphae are affected by relative humidity, only the former change their direction of growth towards a higher relative humidity.
In view of this evidence it is suggested that the physiological change which takes place at the end of the ectophytic stage, i.e. after substomal vesicle formation, is a change in the permeability of the cell-wall. Whether such a change in cell-wall permeability could be responsible for all the differences observed between the ectophytic and endophytic stages of *Puccinia triticina* remains to be investigated.

1250* DUNNING, R. A.
Beet Stem Eelworm.
Plant Path. 1954, **3,** 133–4.
Stem eelworm damage to beet, in various stages of growth, is described and illustrated. A list is given of other host plants of this eelworm (*Ditylenchus dipsaci*), and the source of field infestations is discussed.

1259* JONES, F. G. W.
Quantitive Methods in Nematology.
Ann. Appl. Biol. 1955, **42,** 372–81.
The techniques of soil population estimation, assay of cyst contents and estimation of the numbers of nematodes within plants are briefly reviewed. Control of experimental error in laboratory techniques is relatively easy because sub-samples drawn from bulk soil samples or bulk suspensions of eggs, larvae or free-living nematodes should fit the Poisson distribution. For the estimation of field populations, however, within field variability usually remains unknown. For ' low ' population levels (10 cysts/kg. or 10×10^6 cysts/acre), the methods normally employed and based on samples of the order of 100 g. are very inaccurate. Success in advisory work, where cropping is based on soil population estimates, is attributed to the high critical levels at which crop symptoms appear. At these high levels (potato eelworm, 500×10^6 cyst with contents/acre beet eelworm 100×10^6 cysts with contents/acre) the methods are more accurate and the within-field variability less. In research, control of within-field variability is essential and may be achieved by the use of pots or more naturally by the use of ' microplots '.

1249* JONES, F. G. W., DUNNING, R. A. & HUMPHRIES, K. P.
Effects of Defoliation and Loss of Stand upon Yield of Sugar Beet.
Ann. Appl. Biol. 1955, **43,** 63–70.
Seedling pests of sugar beet cause defoliation and loss of stand. Attempts were made to assess the effects of these types of injury by means of field trials in which the defoliation and loss of stand were produced artificially shortly after singling. The main effects of these treatments were to modify the size of the plants without greatly influencing their percentage of sugar content. Little loss of crop resulted until 50% of the leaf area or 50% of the plant population had been destroyed. The yield from re-sowing after removal of all the plants was inferior to that from stands depleted of half or two-thirds of their initial plant population. The relation between the results of artificial injury and the injury produced by seedling pests is briefly discussed.

1239* Jones, F. G. W. & Humphries, K. P.

Use of Seed Dressings Containing γ-BHC in the Establishment of Sugar Beet Seedlings.

Ann. Appl. Biol. 1954, **41**, 562–77.

From 1949 to 1952 field trials were made to determine the effect of seed dressings containing γ-BHC, with and without the addition of organic mercurial compounds, upon the establishment of sugar-beet seedlings. Most of the trials were made in fields where no serious pest problems were anticipated. The 1949 trials established the concentration of γ-BHC non-phytocidal to sugar-beet seedlings. Later trials tested the effect on pre- and post-singling plant populations of dressings applied to natural or rubbed seed sown at standardised rates. Parallel tests of dressed seed were made on farms representing a variety of soil types. It was found that the phytotoxicity of γ-BHC varied with season and soil type, but that a dressing containing 40% was usually safe.

In these trials, the benefits from seed dressing were, as a rule, slight. Generally the combined mercury γ-BHC seed dressing gave the best pre-singling stand of plants. Most of the improvement was attributable to the organic mercury rather than to the γ-BHC, but where pest attacks occurred, γ-BHC gave marked improvements in stand. Wireworm appeared to be the chief pest controlled : control of pygmy mangold beetle was only partial.

1248* Shepherd, A. M.

Formation of the Infection Bulb in *Arthrobotrys oligospora* Fresenius.

Nature, Lond. 1955, **175**, 475.

Detailed observations and timing have been carried out on the formation of the infection bulb by *Arthrobotrys oligospora* Fresenius within a nematode from the time of capture until the bulb has reached its maximum size. It is suggested that it is unlikely that death of the prey is brought about by mechanical obstruction of the body cavity.

1247* Shepherd, A. M.

***Harposporium crassum* sp. nov.**

Trans. Brit. Mycol. Soc. 1955, **38**, 47–8.

A species of *Harposporium, H. crassum,* with a rather coarse mycelium and crescent-shaped conidia, is described for the first time. An internal parasite of nematodes, the fungus was found in horse dung from Denmark.

1277* Tribe, H. T.†

Studies in the Physiology of Parasitism, XIX. On the Killing of Plant Cells by Enzymes from *Botrytis cinerea* and *Bacterium aroideae*.

Ann. Bot., N.S. 1955, **19**, 351–68.

Enzyme preparations were obtained from culture filtrates of the soft-rot pathogens *Botrytis cinerea* Pers. and *Bacterium aroideae* (Townsend) Stapp grown in simple synthetic nutrient media. Crude culture filtrates and preparations purified by acetone-precipitation and dialysis had three characteristic properties. They (i) decreased viscosity of pectin and pectate solutions, (ii) macerated parenchymatous tissues of higher plants, and (iii) killed cells of tissues so macerated. A parallelism was demonstrated between activity estimated by these three criteria.

B. cinerea enzyme preparations were active from about pH 3·5 to pH 6·0, activity decreasing rapidly from pH 6·0 to nearly nil at pH 8·0. Conversely *B. aroideae* was most active above pH 8·0, activity decreasing progressively to nearly nil at pH 5·5.

Both enzymes lost much activity on prolonged dialysis against distilled water and this was not recovered on readdition of dialysed salts. On dialysis against certain salts or salt mixtures reduced or negligible losses occurred.

Plasmolysing concentrations of salts or non-electrolytes greatly retarded the killing action of the enzyme preparations, the effect being out of all proportion to that on maceration or on rate of pectin degradation.

Protoplasts were isolated in the plasmolysed condition from certain tissues. These were resistant to toxicity in similar manner to those inside the tissues.

1276* Wallace, H. R.

Factors Influencing the Emergence of Larvae from Cysts of the Beet Eelworm, *Heterodera schachtii* Schmidt.

J. Helminth. 1955, **29**, 3–16.

Experiments on larval emergence in a series of constant temperatures showed that, of those temperatures tested, 25°C. was the optimum. Results suggest that constant temperatures do not provide optimum conditions for larval emergence and that a higher rate of emergence may occur under fluctuating temperatures. The rate of larval emergence in beet diffusate increased as the initial oxygen concentration increased. Pretreatment of cysts at low oxygen concentrations reduced the subsequent emergence in diffusate. Fluctuating oxygen concentrations also reduced emergence. The rate of loss of water from cysts in air at different saturation deficiencies was determined and the results suggest that the cyst contents behave like other colloidal systems. By exposing cysts to different saturation deficiencies for a given length of time, the subsequent rate of larval

†Work carried out at the Plant Pathology Lab., Imperial College, London.

emergence in beet diffusate was reduced. A similar result was obtained by pre-treating cysts at a high saturation deficiency for various intervals of time. Larval emergence was found to be dependent on the moisture characteristic of the soil. With increasing particle size, the pressure deficiency necessary for maximum emergence decreased. The bearing which these results have upon emergence of larvae in laboratory experiments and in the soil are briefly discussed.

1275* Wallace, H. R.

Influence of Soil Moisture on the Emergence of Larvae from Cysts of the Beet Eelworm, *Heterodera schachtii* Schmidt.

Ann. Appl. Biol. 1955, **43,** 477–84.

The significance of soil moisture in relation to aeration and larval emergence is discussed. The rate of larval emergence from cysts increased as oxygen concentration increased. A comparison of the moisture characteristics of a mass of cysts and of sand of about the same particle size, showed that water was removed from between both the cysts and the sand particles at 12-16 cm. of water pressure deficiency. There was an indication that water was removed from between the eggs within the cysts at 100–135 cm. of water pressure deficiency. The rate of larval emergence showed a gradual decline as suction was increased beyond 20 cm. of water pressure deficiency. Results suggest that egg hatch is not directly dependent on pressure deficiency and that the presence of free larvae within the cyst inhibits further egg hatch. A technique is described for measuring larval motility in sand. There is a decline in motility when most of the water has been removed from the sand pore-spaces. It is suggested that the relatively low rates of larval emergence at high pressure deficiencies are due to inhibition of larval migration from the cyst by the surface forces of the water film.

1287* Winslow, R. D.

Effects of Some Leguminous Crops on the Soil Population Level of the Pea Root Eelworm.

Plant Path. 1955, **4,** 86–8.

The microplot technique was used to determine the effects of certain leguminous crops on the infestation level of pea root eelworm. Fifteen crops were grown. In the case of peas (2 varieties) and vetch the population level was maintained, indicating that this was the maximum eelworm population which the crops would support under the prevailing conditions. In the case of broad bean, and lentils which are also hosts, the population density fell, indicating that these crops probably have a lower population " ceiling ". Non-host crops, sweet pea, *Lathyrus elymenum*, runner bean, dwarf bean, kidney vetch, lucerne, sainfoin and clover caused a reduction in the population density. Depth of infested soil may be of significance in crop rotation. In a heavily infested field where peas are liable to fail, field beans may succeed by deeper rooting. Vetch can support an undesirably high eelworm population and should not be grown in soil infested with pea root eelworm.

1245* Winslow, R. D.

Hatching Responses of some Root Eelworms of the Genus *Heterodera*.

Ann. Appl. Biol. 1955, **43,** 19–36.

An account is given of investigations on the hatching responses, under laboratory conditions, of nine species or varieties of *Heterodera*, namely, the beet, cabbage, clover, *Galeopsis*, carrot, hop, potato, oat and pea eelworms. In the first seven of these, marked differences occurred in hatching responses from cysts incubated in root leachings from various plants, these differences being virtually diagnostic for the eelworm species concerned. In general, good responses to leachings from host plants occurred, whereas there was little or no response in non-host leachings ; but cases of response to non-hosts and of failure to respond to hosts were encountered. Promising results were obtained in the analysis, by bio-assay, of mixtures of some of these eelworm species. No appreciable response occurred from cysts of oat and pea eelworms incubated in host leachings, but there was some evidence that such a response did occur from pea eelworm cysts under field conditions. Curves for rate of hatching of seven species and for hatching in diluted leachings in five species were found to be of the form described by Fenwick for potato eelworm. Results are given of some experiments on the effect of age of plant on potency of the root leachings, and on the loss of potency during storage.

1278* Winslow, R. D.

A New Method for the Production and Recovery of Cysts of Root Eelworms (*Heterodera* spp.) for Use in Bio-assay.

J. Helminth 1955, **29,** 49–54.

Methods are discussed for greatly increasing the cyst content of *Heterodera*-infested soil, so that very little soil need be " floated " to provide the number of cysts necessary to form a replicate in bio-assay. Such a " float " contains very little debris and may be used directly, thus avoiding the laborious and time-consuming step of separating the cysts from the debris. An apparatus for quick recovery of the " float " is described.

1240* Winslow, R. D.

Provisional Lists of Host Plants of some Root Eelworms (*Heterodera* Spp.).

Ann. Appl. Biol. 1954, **41,** 591–605.

In host-range tests carried out at Cambridge, 1951–3, beet eelworm was found to parasitise nearly all Cruciferae tested, while other hosts were found amongst the Amaranthaceae, Chenopodiaceae, Labiatae, Phytolaccaceae, Polygonaceae, Scrophulariaceae and Tropeaolaceae. Cabbage eelworm parasitised nearly all Cruciferae tested, and a few Labiatae. Hosts of *Galeopsis* and clover eelworms were found amongst the Caryophyllaceae, Labiatae, Leguminosae, Polygonaceae and Scrophulariaceae. Potato eelworm cysts were found

only on *Lycopersicum* and *Solanum* ; carrot eelworm only on *Daucus* ; and hop eelworm only on *Urtica* (Urticaceae) and *Cannabis* and *Humulus* (Cannabinaceae). Pea eelworm appeared to parasitise only the genera *Lathyrus, Lens, Pisum* and *Vicia* (Leguminosae), while hosts of oat eelworm appeared to be distributed more or less at random within the Gramineae.

OTHER PAPERS

JONES, F. G. W. **Beating the Eelworm.** *Brit. Fmr.* 1955, **8** (1), 12–13.
1288* JONES, F. G. W. **Beet Eelworm—Report on a Visit to Germany and Holland.** *Brit. Sug. Beet Rev.* 1955, **24,** 25–8, 39.
JONES, F. G. W. **Control of Wireworms in Beet.** *Brit. Sug. Beet Rev.* 1955, **23,** 113–15.

PLANT BREEDING AND GENETICS

HUDSON, P. S.
Soviet Expert Claims Frost-free Variety.
Grower. 1955, **44,** 395–9.
A brief review of the methods and achievements of the Russian vegetable breeder A. V. Alpatjev is given, with special reference to his work on breeding tomatoes for frost resistance.

1255* HUDSON, P. S.
Sugar Beet. It's a Different Plant Today . . .
Agric. Rev., Lond. 1955, **1,** 31–7.
Advances in sugar-beet improvement, from the selection first applied two centuries ago up to the most recent developments in breeding in various countries, such as the production of monogerm lines and F_1 hybrids, are outlined and the possibilities of further improvements by the new methods are assessed.

RICHENS, R. H.
Studies on *Ulmus*. I. The Range of Variation of East Anglian Elms.
Watsonia 1955, **3,** 138–53.
A taxonomic study of East Anglian elms is presented, based on a systematic sampling procedure covering an area 100 km. square. The degree of taxonomic affinity between the samples collected is worked out by statistical analysis of the significance of the differences of five selected leaf characteristics ; the results are represented graphically in the form of a net work of bars connecting closely related samples.
Eleven taxonomic groups are distinguished within the genus. The species *U. glabra, U. carpinifolia* sens. lat. and *U. procera* are regarded as fairly satisfactorily distinguishable, but the groups recognised both cut across and transcend the microspecies *U. carpinifolia* Melville, *U. coritana* and *U. diversifolia* . A proposal to replace Latin epithets for the subordinate taxa of *U. carpinifolia* sens. lat. by numerical designations is put forward.
The history of elms in England since the Neolithic era is reviewed in the light of phyto-geographical, documentary and philological evidence, and the role of the elm as a forage tree in ancient agricultural practice is discussed.

PLANT ECOLOGY

1243* LAZENBY, A.†
Germination and Establishment of *Juncus effusus* L. Effect of Different Companion Species and of Variation in Soil and Fertility Conditions.
J. Ecol. 1955, **43,** 103–19.
In order to study the effects of competition on the germination and establishment of *Juncus effusus*, seeds of this species were sown alone and with various mixtures of grass and clover species on two soil types and at three fertility levels.
The companion species sown with the *J. effusus* seeds have shown a great influence on initial germination and subsequent development of the seedlings of the latter species.
Different companion species had different effects. The establishment of seedlings varied from 13 seedlings in 24 boxes to 558, and the inflorescence development from nothing to more than 20%. Fewest *Juncus* seedlings established with *Agrostis tenuis* + *Trifolium repens* as companion species, and progressively more with *Lolium perenne* + *Trifolium repens*, and *T. repens* alone, and *Molinia caerulea* + *Trifolium repens* (the seedlings appeared in approximately equal numbers in these two mixtures) and *Juncus effusus* sown alone.
Neither soil nor fertility differences in themselves had any effect on initial establishment of seedlings of *J. effusus*, but in their subsequent development plants of *J. effusus* growing alone produced more herbage under high fertility than under low fertility conditions. Under the management adopted, plants growing with companion species and establishing in the early stages after sowing also grew into larger individuals under conditions of high fertility. However, when companion species were present, fewer *J. effusus* seedlings established in the later stages after sowing, and also there was a higher mortality rate of such seedlings.
Dry weight of companion species has been tabulated and briefly considered in relation to soil and fertility differences.
A short account of an experiment dealing with germination of *J. effusus* seeds in relation to depth of sowing has been presented.

†*Work carried out at the Welsh Plant Breeding Station, Aberystwyth.*

1264* Lazenby, A.†

Germination and Establishment of *Juncus effusus* L. II. Interaction Effects of Moisture and Competition.

J. Ecol. 1955, **43**, 595–605.

In order to study the effects of available moisture on germination and early establishment of *Juncus effusus*, and of competition under these conditions, seeds of *J. effusus* were sown at different water-tables alone and with two mixtures of grass and clover.

There were great differences in the numbers of *Juncus* plants establishing under different conditions of available moisture. At the end of the first experiment 540 seedlings were removed from all mixtures sown with the water-table up to the soil surface, whilst no seedlings established under the very dry conditions produced by a water-table 8 in. (20 cm.) below the soil surface.

Sown species had less influence on initial establishment of *Juncus* seedlings than had available moisture. There were, however, considerable differences in the effects of companion species on subsequent development of the seedlings. The mean weights of seedlings removed from pots of *J. effusus* sown alone, *J. effusus* + *Lolium perenne* + *Trifolium repens*, and *Juncus effusus* + *Agrostis tenuis* + *Trifolium repens*—all with a water-table up to the soil surface—were 96·9, 13·3 and 12·6 gm. respectively, whilst the mean numbers of seedlings removed were 37·0, 28·2 and 24·2.

Counts of plant numbers and air-dry weights were taken of the species sown with *Juncus effusus* and a comparison has been made of the relative germination and subsequent development of these species in relation to *J. effusus* under different conditions of available moisture.

The discussion includes a short account of the practical importance of these results particularly in relation to the data presented in an earlier paper (Lazenby, 1955).

†*Work carried out at the Welsh Plant Breeding Station, Aberystwth.*

SOIL SCIENCE

Bodman, G. B. & Collis-George, N.

Report of Committee on the Physics of Soil Moisture, 1952–3.

Trans. Amer. Geophys. Un. 1953, **34**, 938–44.

The report was drafted by the authors on behalf of the committee, and is a compilation and interpretation of a questionnaire, circulated to Agricultural Colleges and Departments in the United States, Alaska, Hawaii and Puerto Rico, on research in progress in Physics of Soil Moisture.

It is divided into two parts.

Part one lists the topics of work being carried out under 24 class headings, divided into three major categories, viz :—

(*a*) Problems of static equilibrium ;
(*b*) Problems of kinetic equilibrium (steady state) ; and
(*c*) Problems of non-equilibrium and non-steady state.

Part two lists the workers involved, and their distribution by States, as at September 1953.

1210* Childs E. C.

The Physical Principles Underlying Water Table Control.

2nd Congr. Int. Comm. Irrig. & Drainage, Algiers, 1954.

This paper outlines the field of recent research into the physics of water-table control. There are three main lines of enquiry, namely :—

(*a*) The solution of problems in potential theory, defined by the operation of Laplace's equation with boundary conditions characteristic of free surfaces ;
(*b*) The nature of the permeability of porous materials ; and
(*c*) The development of methods of measuring permeability in the field.

The potential problem is simplified by considering separately the regions above and below the water-table ; the latter has been the more intensively studied. The equation of continuity here becomes Laplace's equation, and solutions have been derived by mathematical analysis, by successive approximation (graphical, numerical, and by electric analogue), and by sand model studies.

The criterion of an understanding of permeability is the ability to relate permeability to the pore space geometry and to the degree of saturation. Recent developments of Kozeny's concept are referred to, and a new departure which deals statistically with pore sequences is described.

Reliable field methods of measuring permeability all employ wells or cavities sunk into the groundwater. Analysis of the non-steady flow states following momentary perturbation of the water table provides a measure of apparent permeability. Observation of the steady rate of flow between two neighbouring wells provides a measure of true horizontal permeability, and analysis of the discrepancy between this and the apparent permeability referred to provides a measure of the degree of anisotropy.

1236* Childs, E. C.

The Space Charge in the Gouy Layer Between Two Plane, Parallel Non-conducting Particles.

Trans. Faraday Soc. 1954, **50**, 1356–62.

It is pointed out that there is no justification for the usual assumption that the Gouy layer space charge per unit area of surface which supports it just neutralises the surface charge. The relationship between the

space charge and the particle charge is derived for plane parallel particles, such as many clay minerals, which are non-conducting and in which the charge distribution is constant and symmetrical about a medial plane. The consequent modification of current theory is shown to be small in ordinary circumstances, and the calculation of the potential distribution and repulsive pressure between the plates assuming, as is usual, that the Gouy layer charge is equal to the surface charge, is attended by only negligible error.

It is further shown that, whilst the mutual electrostatic attraction between the surface charge and the space charge cannot, as has been supposed, provide any translational force to the particle, the difference between these attractions on the two sides of a particle does fortuitously give the correct repulsive pressure for the special case of the equipotential particle. The physical nature of the repulsive pressure is shown to be equally perspicuous ; in identical terms, whether the neighbouring particles are entirely immersed in solution and are not in mechanical equilibrium, or whether the solution resides only between the plates, in which case the net repulsion is reduced to zero and the plates are in mechanical equilibrium.

1235* Collis-George, N.

Hydration and Dehydration of Na-montmorillonite (Belle Fourche).

J. Soil Sci. 1955, **6**, 99–110.

Complete moisture-energy relationships for a salt-free Na-montmorillonite at 30°C and partial relationships for the same clay in equilibrium with 0·45 N NaCl were derived by the use of three types of pressure procedures covering different ranges of energy. Specific volumes and basal spacings were determined on clay previously equilibriated with a known pressure.

These results are discussed and a mechanism of clay shrinkage and expansion postulated : this is substantiated in part by the comparison of benzene-water and air-water interfaces. The view of earlier workers that the clay expands or contracts by addition of discrete monolayers of water is supported, the evidence suggesting that different parts of a micelle can have at the same time different numbers of water monolayers between crystal sheets, i.e. they have, simultaneously, two distinct basal spacings. Contrary to other workers it was found that Na-montmorillonite had a maximal spacing of 19·2 Å even in very dilute suspensions, i.e. the ultimate crystal is composed of multiple sheets.

The energy relationships allow calculation of the heats of wetting, of dehydration, and of hysteresis.

A plea is entered for the exact description and treatments of the experimental clay materials by authors.

STATISTICS

1269* Rowell, J. G.

Analysis of a Factorial Experiment (with Confounding) on an Electronic Calculator.

J. R. Statist. Soc. **B**. 1954, **16**, 242–6.

The analysis of a 2^4 factorial experiment confounded into two blocks of two carried out on an electronic computer (the EDSAC) is described. Treatment effects were calculated in the factorial analysis and summarised. The factorial analysis, which would have taken 10 to 12 weeks with a desk machine, was carried out in about 13 days. The summary represented a greater saving of time, being carried out in 3 days.

Three-quarters of the time needed for the computation of the factorial analysis was used in punching the data tapes ; calculators capable of reading from punched cards are available and may be more suited to statistical calculations of this type. No data tape had to be punched for the summary analysis since the input for this was the output of the factorial analysis.

The total machine time needed for the factorial analysis was about four hours.

About 450 orders were used in each part of the analysis leaving storage space for about 190 numbers of 10 decimal digits.

1267* Wishart, J.

The Factorial Moments of the Distribution of Joins between Line Segments.

Biometrika. 1954, **41**, 555–6.

In this paper the author returns to a problem which he originally considered along with H. O. Hirschfeld. This was the finding of the law of probability for the joins which can occur between line segments restricted to be of two kinds only, Thus if consecutive short pieces of a line may be black or white, with given probabilities of one state or the other, a join is a case of black following white, or white following black. A new proof is provided in terms of the generating function of the factorial moments, which has the merit that exact general expressions can be written down for the factorial moments. The corresponding problem in two (or three) dimensions, which is of considerable interest to physicists, still awaits a full solution.

1268* Wishart, J.

Multivariate Analysis.

Appl. Statist. 1955, **4**, 102–16.

The last twenty-five years have seen considerable progress in statistical theory applied to problems in which a number of variables have to be considered simultaneously. Multiple regression is one aspect of this work that is well understood and fairly readily applied, but there are other problems of a more complex nature where the difficulty is that the known solutions involve somewhat intricate mathematics. Knowledge of the computing techniques needed is still not very widely spread. The paper is a general review of what has been

done in the multivariate field, and attempts to unify the presentation of a number of different problems so as to assist in their general understanding, and to encourage workers to use methods where appropriate.

The main topics dealt with are :—

(*a*) the general distribution law of the second-order statistics (variances and covariances),
(*b*) Bartlett's decomposition theorem and its use in regression analysis and polynomial fitting,
(*c*) Hotelling's T^2 generalisation of the familiar " Student " test for the comparison of sample means,
(*d*) the discriminant function and test, now, incidentally, being found useful in ecological studies,
(*e*) Mahalanobis's D^2-test used in the identification and classification problems of the physical anthropologist, and
(*f*) the analysis of dispersion, a name given to the generalisation to many variates of the familiar analysis of variance.

WISHART, J.
The Variance-Ratio Test.
Contr. to *International Statistical Institute.* Summaries of Lectures delivered at the Statistical Seminar held at Rome, September 1953. Pp. 9–12. The Hague, 1955.

MISCELLANEOUS

SALAMAN, R. N.
Obituary by Dr. P. S. Hudson.
Nature, Lond, 1955, **176,** 97.

RICHENS, R. H. & BOOTH, A. D.
Some Methods of Mechanized Translation. Pp. 24–46.
Contr. to *Machine Translation of Languages.* Ed. by W. L. Locke and A. D. Booth. (Wiley, New York, 1955. 48s.)

BOOKS RECEIVED

THE LIBRARIAN HAS PLEASURE IN BRINGING THE FOLLOWING WORKS TO THE READER'S NOTICE

Agricultural Directory of Scotland. 1955 ed. Pp. 423. (Mearns Agric. Publ., Aberdeen. 12s. 6d.)

Agricultural Landowners' Handbook on Taxation. Part I. 9th ed. rev. by J. G. HASTINGS. Pp. 150. (Country Landowners' Assoc., London, 1955. 15s.)

All About Pigs. 800 Questions and Answers. Pp. 372. (Pig Publications, Ipswich, 1955. 7s. 6d.)

ANDERSON, E. **Plants, Man and Life.** Pp. 245, with 16 illus. (Little, Brown & Co., Boston, U.S.A., 1952. $4.)

BATES, R. G. **Electrometric pH Determinations.** Pp. XIII + 331, with many Figs and Tables. (Wiley [Chapman and Hall, London]. 1955. 60s.)

BEAR, F. E. (Ed.). **Chemistry of the Soil.** Pp. X + 373, with Figs and Tables. (Reinhold [Chapman and Hall, London], 1955. 70s.)

BENNETT, H. H. **Elements of Soil Conservation.** 2nd ed. Pp. X + 358, with 108 Figs, 9 Graphs and 17 Tables. (McGraw-Hill, London, 1955. 28s. 6d.)

BLANCK, F. C. (Ed.). **Handbook of Food and Agriculture. Pp.** VII + 1039, with many Figs and Tables. (Reinhold [Chapman & Hall, London], 1955. 100s.)

BOLTON, K. **Outdoor Pig-Keeping.** Pp. 128, with 15 illus. (Pig Publications, Ltd., Ipswich, 1954. 5s.)

British Poultry Standards. Pp. XII + 348, with 4 Colour Plates and numerous illus. (Poultry World, London, 1954. 25s.)

British Tractors and Farm Machinery (The Green Book), 1955. Pp. 324. (Norman Kark Publ., Ltd, London. 40s. including Summer Supplement.)

CALHOUN, M. L. **Microscopic Anatomy of the Digestive System of the Chicken.** Pp. X + 108, with 46 Plates. (Iowa State College Press, Ames, 1954. 20s.)

CHEEMA, G. S., BHAT, S. S. & NAIK, K. C. **Commercial Fruits of India.** Pp. XXVI + 422, with Plates. (Macmillan, London, 1954. 30s.)

CHILDER, N. F. (Ed.). **Mineral Nutrition of Fruit Crops.** Pp. 907, with many Illus., Tables and Bibl. (Horticultural Publications, Rutgers Univ., New Brunswick, 1954. $10.)

COTTIER, W. **Aphids of New Zealand.** Pp. XI + 382, with 98 Figs. (N.Z. Dept Sci. Industr. Res. Bull. 106, 1953. 42s.)

DE LA RIVIÈRE, R. D. & EYQUEM, A. **Les Groupes Sanguins chez les Animaux.** Pp. 407. (Éditions Médicales Flammarion, 22 Rue de Vaugirard, Paris, 1953. Fr.3,275).

Farmer and Stock-Breeder Year Book, 1955. Pp. 404. with numerous Illus. (Farmer and Stock-Breeder, London, 1955. 10s. 6d.)

Farmer's Year Book, Encyclopaedia & Directory of Pedigree Breeders 1954-5. Pp. 432, with 79 Illus. (Tantivy Press, Tibberton, Glos., 1954. 9s. 6d.)

FBI Register of British Manufacturers, 1955. 27th ed. Pp. 1089. (Iliffe & Sons, London, 1954. 42s.)

Feeding the Fifty Million. Report of the Rural Reconstruction Assoc. Research Committee. Pp. 138. (Hollis & Carter, London, 1955. 12s. 6d.)

FELTWELL, R. **Deep Litter for Egg Production.** Pp. 86, with 4 Plates. (Faber & Faber, London, 1954. 6s. 6d.)

FERNALD, H. T. & SHEPARD, H. H. **Applied Entomology.** 5th ed. Pp. X + 385, with 269 Figs. (McGraw-Hill, New York and London, 1955. 52s. 6d.)

FREAM'S **Element's of Agriculture.** 13th ed. revised and edited by D. H. Robinson, Pp. XI + 735, with 59 Plates, 110 Figs, 20 Tables and 4 Appendices. (John Murray, London, 1955. 25s.)

FREAR, D. E. H. **Chemistry of the Pesticides.** 3rd ed. Pp. VI + 469, with 13 Figs and 19 Tables. (Van Nostrand [Macmillan & Co. London], 1955. 56s.)

FUSSELL, G. E. & K. R. **The English Countryman.** Pp. 172, with 76 Illus. (Melrose, London, 1955. 30s.)

GARRAD, G. H. **A Survey of the Agriculture of Kent.** Royal Agric. Society of England. County Agric. Surveys No. 1. Pp. IV + 232, with Plates, Tables, Maps and Graphs. (R.A.S.E., London, 1954. 21s.)

GERRARD, F. (Ed.). **The Book of the Meat Trade.** 2 vols. Vol. 1, pp. XI + 313 ; Vol. 2, pp. VII + 288, with numerous plates and figs. (Caxton Publishing Co., London, 1949 (1955), 75s.)

GOLDEN, E. F. **Broilers—Their Production and Management.** Pp. 112, with 28 Illus. (Poultry World Ltd, London, 1955. 4s. 6d.

HAGEDOORN, A. L. **Animal Breeding.** 5th ed. Pp. XIX + 364, with 42 Figs. (Crosby Lockwood, London, 1954. 18s.)

HARRIS, L. J. **Vitamins in Theory and Practice.** 4th ed. Pp. XXII + 366, with 103 Figs. and 107 Tables. (Camb. Univ. Press, London, 1955. 35s.)

HOLMES, E. Practical Plant Protection. Pp. XII + 252, with 4 Plates. (Constable, London, 1955. 15s.)

HOSKINS, W. G. **Making of the English Landscape.** Pp. 240. with 17 Figs and 82 Plates. (Hodder & Stoughton, London, 1955. 25s.)

ILER, R. K. **Colloid Chemistry of Silica and Silicates.** Pp. XII + 324, with 62 Figs and 20 Tables. (Cornell Univ. Press [Geoffrey Cumberlege, London], 1955. 45s.)

JAMES, W. O. **An Introduction to Plant Physiology.** 5th ed. Pp. VIII + 303, with 82 Figs. (Geoffrey Cumberlege, Oxford Univ. Press, London, 1955. 17s. 6d.)

JOFFE, J. S. **The ABC of Soils.** Pp. IV + 383, with 25 Tables and 12 Illus. (Pedology Publ., New Brunswick, N.J., 1949. $3.80)

KNIGHT, R. L. **Abstract Bibliography of Cotton Breeding and Genetics 1900–1950.** Pp. 256. (Commonw. Agric. Bureaux, Farnham Royal, 1955. 21s.)

LAING, J. A. **Fertility and Infertility in the Domestic Animals.** Pp. XII + 256, with 27 Illus. and 27 Plates. (Baillière, Tindall & Cox, London, 1955. 35s.)

McELROY, W. D. & GLASS, B. (Ed.). **Amino Acid Metabolism.** Pp. XVI + 1048, with many Figs and Tables. (Johns Hopkins Press [Geoffrey Cumberlege, London], 1955. 100s.)

McKAY, R. **Potato Diseases.** Pp. X + 126, with 107 Figs. (Irish Potato Marketing Co., Dublin, 1955. 21s.)

MILLAR, C. E. **Soil Fertility.** Pp. XI + 436, with 54 Figs and 118 Tables. (Wiley [Chapman and Hall, London,] 1955. 54s.)

MOHR, E. C. J. & VAN BAREN, F. A. **Tropical Soils.** Pp. 498, with 4 Plates, 103 Figs and 143 Tables. (Interscience Publ., London. 1954. 61s.)

MOUAT, G. C. & COLEMAN, F. **Tillage Implements.** Pp. XI + 170, with 65 Illus. and 16 Plates. (Temple Press, Ltd., London, 1954, 21s.)

MUENSCHER, W. C. **Weeds.** 2nd ed. Pp. XVI + 560, with 135 Figs. (Macmillan & Co., London, 1955. 70s.)

PARKINSON, T. H. **Diesel Maintenance.** 4th ed. Pp. 214, with 123 Illus. (Iliffe & Sons, London, 1955. 12s. 6d.)

Practical Poultry Keeping. 5th ed. Pp. IX + 182, Illustrated. (Poultry World Ltd, London, 1955. 10s. 6d.)

REID J W. **Pigs.** Pp. XI + 206, with 10 Illus. and 27 Tables. (Spon, Ltd, London, 1955. 18s.)

RHOAD, A. O. (Ed.). **Breeding Beef Cattle for Unfavorable Environments.** Pp. XIV + 248, with many Figs and Tables. (Univ. of Texas Press, Austin, 1955. $4.75.)

ROSE, G. J. **Crop Protection.** Pp. XXI + 223, with 113 Illus. some coloured. (Leonard Hill, London, 1955. 30s.)

ROY, J. H. B. **The Calf.** Pp. 79, with 11 Figs, 13 Plates and 13 Tables. (Farmer and Stock-Breeder Publ., London, 1955. 5s.)

SAMPSON, H. O., MOWERY, A. S. & KUGLER, H. L. **Farm Shop Skills in Mechanized Agriculture.** Pp. 396, with numerous Figs. (Technical Press, Ltd, London, 1955. 40s.)

SANDERSON, F. H. **Methods of Crop Forecasting.** Pp. XIV + 259, with 12 Figs and 6 Tables. (Harvard Univ. Press [Geoffrey Cumberlege, London,] 1954. 40s.).

SHEEHY, E. J. **Animal Nutrition.** Pp. VIII + 732, with Figs and Tables. (Macmillan, London, 1955. 30s.)

SIMMONS, N. O. **Compound Milling and Associated Subjects.** Pp. XIX + 279, with 197 Illus. including some in colour. (Leonard Hill, London, 1955. 42s.)

SMITH, D. H. **The Modern Diesel.** 12th ed. Pp. 256, with 210 Illus. (Iliffe, London, 1954. 12s. 6d.)

SMITH, R. W. **Accounts and the Practical Farmer.** Pp. 88. (Gee, London, 1955. 10s.)

SOUTHWELL, P. H. **Engineering in Agriculture.** Pp. XII + 260, with 90 Illus. and 6 Tables. (Temple Press, London, 1955. 30s.)

STAMP, L. D. **Man and the Land.** Pp. XVI + 272, with 24 Coloured Plates and 32 other Plates. (Collins, London, 1955. 25s.)

STURKIE, P. D. **Avian Physiology.** Pp. XII + 424, with 77 Illus. (Baillière, Tindall & Cox, London, 1954. 48s.)

THORNE, D. W. & PETERSON, H. B. **Irrigated Soils.** 2nd ed. Pp. XII + 392, with 78 Figs, 64 Tables and Glossary. (Constable, London, 1955. 45s.)

TURNER, C. D. **General Endocrinology.** 2nd ed. Pp. XI + 553 with 171 Figs. (W. B. Saunders Co., London, 1955. 56s.)

WAKSMAN, S. A. (Ed.). **Perspectives and Horizons in Microbiology.** Pp. X + 220. (Rutgers Univ. Press, New Brunswick, 1955. $3.50)

WALKER-WATSON, W. **Finance of Land-ownership .** Pp. X + 245, with 6 Appendices. (Warne, London, 1954. 21s.)

WAY, R. F. **Anatomy of the Bovine Foot.** Pp. 58, with 28 Plates. (Pennsylvania Univ. Press [Geoffrey Cumberlege, London], 1954. 32s.)

WILDMAN, A. B. **Microscopy of Animal Textile Fibres.** Pp. VIII + 209, with 235 Half-tone, 11 Colour Photomicrographs and 88 line drawings. (Wool Ind. Res. Assoc., Leeds, 1954. 42s.)

WILLIS, S. J. **Weed Control in Farm and Garden.** Pp. 184, with 20 Illus. and 16 Figs. (Vinton, London, 1954. 8s. 6d.)

WORMALD, H. **Diseases of Fruits and Hops.** 3rd ed. Pp. 325, with 48 Plates and 24 Figs. (Crosby Lockwood, London, 1955. 25s.)

WYLIE, J. C. **Fertility from Town Wastes.** Pp. 224, with 5 Figs, 35 Illus. and 14 Tables. (Faber & Faber, London, 1955. 25s.)

LIBRARY LACUNAE

The Librarian would welcome gifts or offers of any of the following items :—

Agricoltura delle Venezie. Vol. 1, No. 1-2 ; 5, Nos. 1, 3.

American Society of Animal Production. Record of Proceedings. 1908–1926, 1929–30.

Annales de l'Ecole Nat. d'Agric. de Grignon. Ser. 3. Tome 2.

Annales de l'Institut de Recherches Agron. de Roumanie. Vol. 14.

Annales des Épiphyties. Vol. 12, No. 4 ; 14, No. 2.

Archief v. Rubbercultuur. Vol. 25. No. 6.

Archiv d. Deutschen Landwirtschafts—Gesellschaft. No. 9.

Aslib Book List. Vol. 1, No. 4 ; 6, No. 1 ; 7, No. 3.

Bibliography of Agriculture. Washington. Vols. 1–2.

Biologe (Der). Vol 4. Nos. 1-4.

Biological Bulletin. Vol. 53. No. 1.

Biological Symposia. Vols. 2–3.

Bodenkunde u. Pflanzenernährung. Vol. 34, Nos. 3–6 ; 35, Nos. 5–6 ; 36.

Botaničeskii Žurnal, U.S.S.R. Vols. 21-22.

Botany and Zoology (Tokyo). Vols. 8, No. 11 ; 9, Nos. 1, 8-12 ; 10, Nos. 1–12 ; 11, Nos. 1–12.

Bull. American Soil Survey Assoc. Nos. 1–5, 10–11.

Bull. Soc. Scient. d'Hygiene Alimentaire. Vol. 31. Nos. 1-3.

Canada. Nat. Res. Council. Bibliography on Soil Mechanics.

Cytologia. Vols. 10, No. 3 ; 11–13 ; 14, Nos. 1–2 + Fuji Memorial Vol.

Current Science. Vol. 21, Nos. 5–12 :

Econ. Proceedings Royal Dublin Society. Vol. I. No. 6.

Farm and Forest (Nigeria). Vol. 2, Nos. 3–4 ; 3, Nos. 1–4 ; 4, Nos. 1–4.; 5, Nos. 1–3.

Farming in South Africa. Vol. 2. No. 17.

Fecondazione Artificiale. Vol. 4, No. 6 ; 5, Nos. 8, 12.

Genetics. Vol. 4. pp. 95-204.

Handbuch d. Bodenkunde. Vols. 1-10.

Handbuch d. Pflanzenzüchtung. Nos. 10–26.

Indian J. of Agricultural Economics. Vol. 1, No. 1.

Intern. Mitteilungen f. Bodenkunde. Vol. 5, 8-11.

Iowa Agric. Exp. Stat. Bull. 240.

L'Italia Agricola. Vol. 70. Nos. 1-9 ; 75, No. 2.

J. f. Landwirtschaft. Vol. 88, 1942.

J. of Physiology. Vol. 101, No. 2 ; 104, No. 3 ; 107, No. 3.

J. of the Agric. Assoc. of China. Nos. 164, 176.

J. of the College of Agriculture. Tokyo Univ. Vol. 14, No. 6 ; 15, 1–2.

J. of the South-Eastern Agric. College. Nos. 1-2, 4-8, 11.

J. of Heredity. Vols. 1-4 ; 5, Nos. 1-7. (Vols. 1-4 issued as Amer. Breeders' Mag.)

J. Pomology and Hort. Science. Vol. 1. No. 1.

J. Royal Hort. Soc. Vol. 58.

Jute Abstracts. Vol. 7. No. 4.

Kartoffelbau. Vol. 1, No. 1.

Kühn Archiv. Vols. 6-8, 57, 59.

Kulturtechniker. Vol. 42, Nos. 9–12 ; 44, Nos. 5–6.

Lloydia. 12, No. 3.

Maatalous ja Koetoiminta. No. 5.

Mémoires de l'Acad. Polonais. Ser. B. No. 4.

Nachrichtenblatt f. d. Deutschen Pflanzenschutzdienst. Vol. 3, Nos. 1–4, 11–12.

Natural and Applied Science Bulletin (Philippines). Vol. 8, No. 3.

Norfolk Agric. Exp. Stat. Bull. Nos. 2–3.

North Dakota Bi-Monthly Bulletin. Vol. 2, No. 6.

Nova Acta Leopoldina. Vol. 10. No. 65.

Philippine J. Agric. Vol. 10 (Index) ; 12, No. 3.

Philippine J. Animal Husbandry. Vol. 8, Nos. 4–5.

Proc. Amer. Soc. Hort. Science. Vol. 53.

Proc. Crop Science Soc. Japan. Vol. 11, No. 4 ; 13, Nos. 1–4 ; 14, No. 2 ; 17, Nos. 2–3.

Proc. Inst. British Agric. Engineers. Vols. 1–2 ; 3, No. 7.

Proc. N.Z. Grassland Assoc. 11th, 12th.

Proc. N.Z. Soc. of Animal Production. 2nd, 9th.

Proc. Royal Society. *B.* Vol. 134, No. 874.

Publicatie v. Comm. v. h. Kunstmatig Drogen v. Gras. Nos. 4, 6.

Revista Agronomica, Lisbon. Vol. 35, No. 1.

Risicoltura (Vercelli). Vol. 32. Nos. 7-9.

Rivista di Zootecnia (Firenze). Vol. 18, Nos. 11–12 ; 19, Nos. 1–2.

Scientific Agriculture. Vols. 1–3 ; 4, Nos. 1–5, 8 ; 5, Nos. 2–3, 6–7, 9–12 ; 6, 7.

Southern Seedsman. Vol. 17. Nos. 3–4.

Sveriges Pomologiska Förenings Årsskrift. 1942, 1943.

Trans. Amer. Assoc. Cereal Chemists. Vol. 1, Nos. 1–2 ; 2, Nos. 2, 4.

U.S. Bur. of Soils. Bull. 45 (1907).

U.S. Dept. Agric. Circ. 524, 525 ; Technical Bull. 336, 428.

Věstník Česk. Akad. Zemědělské. Vol. 15. Nos. 1-2.

Welsh Plant Breeding Station. Bulletin. Ser. H. No. 1.

Z. f. Induktive Abstammungs— u. Vererbungslehre. Vol. 77, Nos. 2–4 ; 78, Nos. 1–4 ; 79, Nos. 2–3.

Z. f. Pflanzenbau u. Pflanzenschutz. Vol. 3, No. 2.

Z. f. Tierzüchtung u. Züchtungsbiologie. Vol. 48, No. 3.

Züchtungskunde. Vol. 14, Nos. 9–11 ; 19, Nos. 9–12.

AUTHOR INDEX

Adams, C. E., 16–17
Averill, R. L. W., 16

Barnard, C. S., 12
Bodman, G. B., 24
Brookes, A. J., 14–15

Campbell, R. C., 14, 16
Childs, E. C., 24–25
Clarke, G. B., 12
Cock, A. G., 13
Colling, A. W., 20
Collis-George, N., 24–25

Dickinson, S., 20
Dunning, R. A., 20–21

Engledow, F. L., 12

Farm Economics Branch, 11–12

Gilmour, D. G., 14

Halley, R. J., 15
Halnan, E. T., 15
Hammond, J., 14, 16–17, 20
Hanley, F., 5–10, 12
Harrington, G., 15, 17, 19
Hudson, P. S., 23, 26
Humphries, K. P., 20–21
Hunter, G. L., 14, 17

Jones, F. G. W., 20–21, 23
Joubert, D. M., 14, 18–19

Labban, F. M., 19
Lazenby, A., 23–24

Mackness, R. A., 11–12
Mansfield, W. S., 20
Maqsood, M., 19

Nix, J. S., 12

Pease, M. S., 14
Pomeroy, R. W., 17, 19

Richens, R. H., 23, 26
Rowell, J. G., 25
Rowson, L. E. A., 16–17, 19–20
Roy, A., 19–20

Shepherd, A. M., 21
Sturrock, F. G., 12

Tribe, H. T., 21

Wallace, D. B., 12
Wallace, H. R., 21–22
Whetham, E. H., 11–12
Winslow, R. D., 22–23
Wishart, J., 25–26

PUBLICATIONS

Agricultural Periodicals of the British Isles, 1681-1900, and their Location. Compiled by F A BUTTRESS Price 2*s*

Handbook to the School of Agriculture, containing full information as to the Ordinances governing the teaching, examinations and other activities of the School of Agriculture ; and in addition general information concerning the study of Agriculture at Cambridge. Price 2*s*. 6*d*.

School of Agriculture Memoirs

Nos. 1–10 Price 1*s* 2*d*. each. Post Free. (*Nos*. 1-3, 6, 10 *out of print*).
Nos 11–12. (*out of print*)
Nos 13–14. Price 6*d*.
Nos. 15–17 Price 3*s*.
Nos 18–20. Price 2*s* each.
Nos. 21–26. Price 2*s*. 6*d*. each. (*No*. 24 *out of print*).

All the above are obtainable from the Secretary, School of Agriculture, Cambridge.

For publications of the Cambridge University Agricultural Society and other organisations associated with the School of Agriculture applications should be made as follows :

Cambridge University Agricultural Society
The Secretary, C.U.A.S., School of Agriculture, Cambridge, England.

Commonwealth Bureau of Plant Breeding and Genetics
The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge, England.

Provincial Agricultural Economics Service
The Secretary, Provincial Agricultural Economics Service, School of Agriculture, Cambridge, England.

R. I. Severs, Ltd., Cambridge